# LEY FARMING IN SWEDEN
# A FIELD DAY AT SVALÖF

**BULLETIN 33**

OF THE

IMPERIAL BUREAU OF PASTURES AND FORAGE CROPS
ABERYSTWYTH, GREAT BRITAIN

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An abridged English edition authorized by the Director of the Swedish Seed Association (Sveriges Utsädesföreningen, Svalöf).

Translation made by R. Peter Jones, Welsh Plant Breeding Station, Aberystwyth.

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## FOREWORD

The Swedish workers in research pertaining to grassland husbandry and fodder production have long been regarded as among the leaders in these fields of agricultural investigation. Unavoidably, during the war years since 1939, they have been isolated from the British Commonwealth, the United States of America, and the other countries especially interested in the progress of their research work and the development of new methods and ideas. Although abstracts of most of the scientific articles published in Sweden during this period have appeared in *Herbage Abstracts*, it was felt that some more detailed accounts would be appreciated. Arrangements have therefore been made with the Director of the Institute at Svalöf, through Dr. G. Nilsson-Leissner, for the publication of an abridged English version of the collection of papers read at a Field Day devoted to ley farming, held at Svalöf in June, 1943. The original Swedish versions of these papers were published in *Sveriges Utsädesförenings Tidskrift*, Vol. 53, No. 5, 1943 (see list on p. 44).

In his introduction to this series, Dr. G. Nilsson-Leissner states that four years previously the Seed Association arranged a Field Day at Svalöf to discuss more particularly the many problems that had arisen with regard to new methods of conserving ley products. As this Field Day had proved very successful, and as much additional experience had been gained subsequently in the sphere of ley cultivation and the experiments with herbage plants had shown exceptionally good results, it was decided to call another conference on the ley problem in 1943. On this occasion, a wider field was covered by the inclusion of specialists in crop cultivation and animal nutrition.

The Director of the Swedish Seed Association, Dr. Å. Åkerman, opened the discussion with a statement of the extent to which Sweden depends upon the products of ley farming, and how the difficulties connected with the isolation of the country during the war have been overcome. Dr. G. Nilsson-Leissner followed with a report of the strain trials with red clover carried out in Scania, the southernmost province of Sweden, with particular reference to the adaptability of various early, medium-late and late strains to that latitude. Similar trials with timothy at the branch stations of the Association throughout Sweden were described by G. Julén. Both authors stressed the importance of choosing varieties adapted to the latitude in which the ley was to be grown. With regard more especially to red clover, Dr. A. Elofson stated that it had been the policy of the Swedish Grassland Society to recommend that farmers in possession of local strains should not exchange these for others until the cultivation value of the latter has been proved. Full details of all the improved and other strains of herbage and fodder plants in Sweden are at present being collected by Dr. Nilsson-Leissner for publication with similar details from other countries in a special Bulletin of the Pasture Bureau now in preparation.

G. Rappe gave a paper containing his views on the causes of the seasonal variation in the growth of pastures during critical periods in the summer, a problem that is also receiving attention in Great Britain, the eastern States of U.S.A., eastern Canada and elsewhere. This discussion was concerned

with the effect of management, type of manuring, rainfall, and height of the water table on the extent of the midsummer depression.

N. Olsson described the scope of the research carried on under the auspices of the Nordiske Jordbrugsforskeres Forening (Association of Scandinavian Agricultural Research Workers) on the carotene content of forage plants; investigations on this subject have been begun at Svalöf and its branch-stations, at the Agricultural College, Ultuna, and at the Research Laboratory in Copenhagen.

Problems relating to the effect of ley fodder on the taste and aroma of milk and on its butter- and cheese-making qualities were discussed by A. Örborn; an abridged translation of this paper is provided. The paper by F. Jarl on experiments in fodder conservation is also dealt with briefly, as this question has been the subject of a later Field Day at Svalöf, to which more detailed attention will be paid in a later publication from the Pasture Bureau (see below).

The final article published in this Bulletin asks whether sugar beet is in a class apart as a fodder producer. The conclusion drawn by P. A. Olsson is that this crop certainly possesses a high cultivation value as fodder, but that it is far from being in a class apart; only when the yield of tops is harvested in the most careful manner possible does it reach the level of the better strains of fodder beet and mangolds. (This article was not presented at the Field Day, but was published in the same issue of *Sveriges Utsädesförenings Tidskrift*, and a translation is included although it is not directly concerned with leys.)

As already stated, a Fodder Conservation Day was held at Svalöf on June 10, 1944 (*Lantmannen Svenskt Land*. 28. 586. 1944). Among the 300 participants were practical farmers from Scania and neighbouring counties, representatives of "Milk Propaganda," Messrs. Pehrson and de Laval—designers of driers, advisers, teachers and others.

Professor Åkerman emphasized the need for increased production of protein-rich fodders, partly through the cultivation of oleiferous crops, and partly by an increase in the protein content of ley fodder. With regard to the latter, it is also desirable to reduce the fibre content and increase the degree of concentration by means of better leys of more suitable composition and by better and more rational curing of the ley crops.

M. O. Nordenborg referred to the experiences of harvesting methods during recent years and stated that Scanian farmers had much to learn from Uppland farmers as far as ley crops and cereals were concerned. The cheapest methods unfortunately entail the greatest loss of nutrients. The A.I.V. method entails a loss of only 15 per cent, a figure which need not be exceeded if drying on hurdles is properly carried out. The cost of hurdle-drying is only about 10 kr. per ha. higher than that of drying in cocks.

In the subsequent discussion, speakers emphasized the advantages of hurdle-drying. Professor Forsberg stressed the fact that drying poles had great advantages in the lowlands in situations exposed to the wind owing to the better utilization of timber and the greater saving of labour.

Dr. G. Nilsson-Leissner dealt with the production of suitable plant material for the different methods of conservation. The importance of the initial material has increased with the adoption of modern methods of conservation. Another change is that in recent years farmers have been interested in crops which are cut several times during the summer, and also in non-synchronizing ley mixtures ; by alternating cutting of the majority of these, continuous running of the driers can be maintained during longer consecutive periods, the fodder being during the whole time in the most suitable stage of development.

Professor J. Axelsson discussed different methods of conservation from the point of view of feeding, dealing in detail with the composition and value of ley fodder. It is primarily a matter of increasing the protein content of the ley fodder and by that means enhancing its effect in feeding. The same result can be attained by reducing the fibre content. The various methods of conservation provide different possibilities in these respects. Early cutting is a method which cannot be fully utilized in ordinary haymaking. In the preparation of A.I.V. silage and in artificial drying on the other hand, the ley can be cut in a very early stage.

C. A. Kleist gave high praise to the A.I.V. method. As a result of its use there had been a considerable increase in milk production and it was computed that a saving of 13,000 tons of imported concentrated feeding stuffs had been effected.

The opinions of practical farmers about the methods of conservation were expressed by G. Christensson, Hyllinge, and G. Jacobsson, Björka. The former stated that artificial drying now costs 15 öre per kg. dried material compared with 5 öre before the war, and that in spite of the high cost the method is economically justifiable. G. Jacobsson dealt with the rationalization of the preparation of A.I.V. fodder and recommended the use of silos each large enough to provide fodder for six weeks. A.I.V. fodder gives summer milk all the year round.

# THE FODDER SITUATION IN SWEDEN

Å. Åkerman

In Sweden cattle farming and the country's extensive production of milk and butter are directly dependent on ley cultivation. Of the 3,750,000 hectares of arable land, approximately 1,600,000 hectares, or 42 per cent, are used for hay leys ; there is in addition an area of natural meadow of slightly more than one million hectares.

The yield from the leys on arable is calculated to amount on the average to 3,000 million food units a year, containing more than 400,000 tons digestible protein : the yield from natural meadowland amounts to approximately 700 million food units with nearly 60,000 tons digestible protein. The great importance of the leys for the country's supply of dairy products is shown by the fact that Sweden's import of oilcakes during the years immediately before the war, which amounted to 300,000 tons, meant a contribution of only about 400 million food units.

One of the reasons that Sweden's position in regard to her milk supply is so much better than during the previous blockade is certainly to be looked for in the marked development of pasture cultivation.

In regard to winter foddering the position is not nearly so favourable. During the past winter (1942–43) the distribution of oilcakes has been only about one-third of the normal consumption. For the next consumption year the supply will probably be slightly more sparse than previously. It is, therefore, of the greatest importance that an effort should be made to produce fodder of such good quality that oilcakes can be dispensed with, while at the same time milk production does not suffer.

Since the outbreak of war different methods of obtaining a substitute for imported fodder have been tried. In the preparation of A.I.V. silage, if the fodder is sufficiently tender when cut, silage with only 20 to 25 per cent fibre and 18 to 20 per cent protein in the dry matter is obtained, that is, fodder of the quality the animals need for satisfactory milk production.

The vitamin A content of the milk is entirely dependent on the fodder's content of carotene. In winter milk the vitamin A content is much lower than in summer milk : the carotene is to a great extent destroyed during hay curing. With the preparation of A.I.V. silage, the carotene is preserved and stored with very small losses. This method of conservation should, however, not be regarded as merely an emergency measure. All possible steps should be taken to increase the vitamin A content of winter milk, and this should be done primarily by devoting more attention to modern methods of fodder conservation.

# TRIALS WITH RED CLOVER STRAINS IN SCANIA

G. Nilsson-Leissner

The present report is based in the main on the series of trials with strains of red clover which were carried out during the period 1934–40 by the Scanian Seed Growers' Association with the assistance of the Royal Academy of Agriculture. These trials were planned and conducted by L. Aronson and collated by me and an account of them will be published in *Kungl. Lantbruksakademiens Tidskrift*. The results of other trials conducted in Scania, chiefly at Svalöf and Weibullsholm, and in the course of the years reported on by the investigators there, have also been reviewed. [Scania is the southernmost province in Sweden.]

The trials of the Seed Growers' Association were laid out during the period 1934–38 at five or six places each year and harvested during the two subsequent years. They comprised twenty-five to thirty-two different strains, divided into four groups, of which the one which included the early strains was cut three times a year and the others twice. The size of the plots was 10 sq. m. and the number of replications five. Sowing was always carried out in a cereal nurse crop. The experimental centres which varied slightly were: Svedberga, Landskrona, Svalöf, Teckomatorp, Trollenäs, Wennberga, Fredriksberg, Wemmenhög and Hammenhög, so that the testing may be said to have included the whole of the Scanian south-west lowlands from Kullen in the north-west to Österlen in the south-east.

The strains tested comprised three Scanian local strains: Karaby, Spannarp and Harrie; two strains from Svalöf: Svalöf Purebred and Mercury; two from Weibullsholm: Smaragd and Resistant; three from Otto J. Olson and Son, Hammenhög: Essi, Lindby 30/315 and T (b + c); one from Carl Engström Co., Ltd., Eslov: E.I.; in addition a local strain from Blekinge: Wambåsa; from Östergötland: Sörby, Björnsnäs and Väversunda; from Västergötland: Hassle-Säby and Traneberg, from Närke: Ormesta and Hättinge; from Uppland, Ultuna; and from Värmland: Labberud, Mellbyn and N. Edsberg. Of the remaining central Swedish strains, Göta clover from Algot Holmberg and Sons, Norrköping, and the Danish Hersnap strain grown on in Östergötland were included. The Danish medium-late "Ötofte halvsildig" (=medium-late) and "sildig" together with "Tystofte halvsildig" and the early Lofa, Tystofte No. 40, Ötofte early, Fionia and Hinderupgaard were also tested in addition to four lots of so-called Silesian red clover deriving from Poland, Bohemia and Russia and also the Binga strain grown on in the county of Kalmar. The results, which are presented in Tables 1 and 2, can be summarized in the following way.

No distinct differences between the results from the various experiment centres could be determined. The numerical material has therefore been combined and treated as though it represented one single experimental area.

## Late and Medium-late Strains

(see Table 1)

These trial groups comprised in all twenty-nine strains, three of which, however, were of the earlier type. The Harrie strain was the check variety.

The most striking fact in this table is that all the central Swedish strains (in the table the last twelve beginning with Göta clover) are in both the first and second year leys inferior to the Harrie strain by 10 to 20 per cent or more, and thereby also inferior to the local and improved strains of Swedish and Danish origin best suited to Scania. For that reason no further analysis of the results of trials with these strains has been carried out. The central Swedish strains are clearly of no interest as far as Scanian ley cultivation is concerned.

TABLE 1

Yield in tons green mass per ha. of the Harrie strain together with differences between it and other medium-late strains.

(Rel. No. : Harrie=100.)

| Strain | First Year Ley, Total Yield | | | | Second Year Ley, Total Yield | | | |
|---|---|---|---|---|---|---|---|---|
| | No. of trials | Harrie t/ha | Difference t/ha | Rel. No. | No. of trials | Harrie t/ha | Difference t/ha | Rel. No. |
| Karaby | 27 | 43·82 | + 0·98* | 102·2 | 10 | 32·04 | + 1·24* | 103·9 |
| Ötofte sildig | 16 | 48·41 | + 2·31** | 104·8 | 8 | 33·91 | + 3·65* | 110·8 |
| ,, halvsildig | 26 | 44·18 | + 1·65*** | 103·7 | 11 | 31·60 | + 4·66** | 114·7 |
| Spannarp | 27 | 43·82 | — 0·33 | 99·2 | 10 | 32·04 | + 1·96 | 106·1 |
| Svalöf Purebred | 27 | 43·82 | + 0·15 | 100·3 | 10 | 32·04 | — 1·17 | 96·3 |
| Smaragd | 27 | 43·82 | — 1·01* | 97·7 | 10 | 32·04 | — 2·62 | 91·8 |
| Resistant | 12 | 46·85 | + 0·93* | 102·0 | 4 | 25·05 | + 7·00* | 127·9 |
| Mercury | 10 | 44·96 | — 0·33 | 99·3 | 3 | 25·43 | + 3·47 | 113·6 |
| Engström E I | 10 | 44·96 | — 4·71*** | 89·5 | 3 | 25·43 | + 0·30 | 101·2 |
| Hammenhög T (*b* + *c*) | 17 | 43·15 | — 2·25*** | 94·8 | 7 | 34·87 | — 2·11 | 93·9 |
| Lindby 30/315 | 16 | 48·41 | — 0·67 | 98·6 | 5 | 29·54 | — 3·06* | 89·6 |
| Hersnap, Ög. | 10 | 44·96 | + 1·45 | 103·2 | 3 | 25·43 | + 0·87 | 103·4 |
| Tystofte halvsildig | 10 | 44·96 | + 2·21** | 104·9 | 3 | 25·43 | + 1·90 | 107·5 |
| Tystofte No. 40 | 5 | 36·98 | — 3·54 | 90·4 | 2 | 25·45 | + 3·80** | 114·9 |
| Lofa | 5 | 36·98 | — 2·56 | 93·1 | 2 | 25·45 | — 1·60** | 93·7 |
| Wambåsa | 26 | 44·18 | — 2·68 | 93·9 | 11 | 31·60 | — 1·88 | 94·1 |
| Göta 185/10 | 27 | 43·82 | — 4·94*** | 88·7 | 10 | 32·04 | — 3·32* | 89·6 |
| Sörby, Ög. | 22 | 45·38 | — 3·64*** | 92·0 | 4 | 25·05 | — 2·88 | 88·5 |
| Väversunda, Ög. | 7 | 36·70 | — 4·16** | 88·7 | 3 | 25·43 | — 5·37 | 78·9 |
| Björnsnäs, Ög. | 27 | 43·82 | — 3·18*** | 92·7 | 7 | 34·87 | — 5·77 | 83·5 |
| Hassle-Säby, Vg. | 26 | 44·18 | — 4·04*** | 90·9 | 9 | 33·90 | — 1·06 | 96·9 |
| Traneberg, Vg. | 10 | 44·96 | — 4·12*** | 90·8 | 1 | 33·80 | — 4·10 | 87·9 |
| Ormesta, Närke | 27 | 43·82 | — 4·10*** | 90·6 | 6 | 36·12 | — 4·95 | 86·3 |
| Hättinge, Närke | 27 | 43·82 | — 7·31*** | 83·3 | 5 | 29·54 | — 6·82* | 76·9 |
| Ultuna, Uppland | 27 | 43·82 | — 4·64*** | 89·4 | 7 | 34·87 | — 3·50 | 90·0 |
| Labberud, Värml. | 27 | 43·82 | — 9·40*** | 78·5 | 5 | 29·54 | — 9·78* | 66·9 |
| Mellbyn ,, | 27 | 43·82 | — 6·68*** | 84·8 | 5 | 29·54 | — 6·94 | 76·5 |
| N. Edsberg, Värml. | 6 | 51·65 | —12·80*** | 75·2 | 1 | 33·80 | —12·50 | 63·0 |

*** denotes a difference so certain that the odds are 1,000 to 1 in favour of its existence.

** denotes odds of 100 to 1, and * of 20 to 1. No * denotes uncertain differences.

As is known, the early red clover strains are characterized primarily by a higher yield in the after-cut than the late and the medium-late strains. At the late date when the main cut in these trial groups was generally taken (June 30 to July 1) the early strains, even though they have overwintered well, give in the first cut a lower yield throughout than the medium-late. In spite of the fact that in the second cut they give a higher yield than the check variety,

in total yield for the year they are not equal to it. See the figures for Tystofte No. 40, Lofa and Wambåsa in Table 1 compared with the check variety Harrie. From this it would appear that in Scania, when choosing a red clover strain, there is but little reason to select an early one if only two cuts are taken in the year and if the first cut is not taken before July 1. A comparison between the three strains shows that the Wambåsa strain is superior in the main cut to the other two, which appear to be of equal value.

Among the strains tested in a large number of trials, Karaby, Ötofte Sildig and Halvsildig (see Table 1) are clearly the highest yielding in comparison with the Harrie strain in both first and second year leys. Ötofte Sildig has already been withdrawn by the breeder and the other two strains are of almost equal value. Ötofte Halvsildig, however, throughout and especially in the second cut of the second year ley shows a marked tendency to give a higher yield than Karaby.

Another group of strains which can be distinguished in Table 1 and of which all appear to be practically equally high yielding are Harrie, Spannarp, Svalöf Purebred and Smaragd. These also were tested in a large number of trials. In the first cut of the second year ley, however, the Spannarp strain shows undeniably a certain superiority, while Svalöf Purebred and Smaragd are inferior. This agrees well with the results obtained in the Svalöf trials.

The seven remaining strains in Table 1 were tested for only part of the experimental period. The following conclusions may be drawn concerning them. Lindby and Hammenhög T (b + c) are obviously inferior to the check variety in both 1- and 2-year leys. Mercury and Resistant appear in the first year ley to be approximately equal to Harrie, but in the second year ley are quite considerably superior to that strain. Tystofte Halvsildig gives a better yield than the check variety in both leys. Engström E I is clearly inferior in the first year ley and probably also in the second year ley. The Hersnap strain from Östergötland appears to be slightly superior to the Harrie strain.

To sum up, it can be said of the late and medium-late strains that the late central Swedish strains possess no interest for clover growers in the Scanian lowlands. In 2-year leys the medium-early and early strains are inferior to the medium-late. Of the latter, testing has shown that the improved and clover parasite-resistant strains, Resistant, Mercury and Ötofte Halvsildig, have throughout given the best results, and that of the local strains Karaby in particular is good, Spannarp also is good, while Harrie is poorer. The Hersnap strain grown on in Östergötland and Tystofte Halvsildig belong to the medium-late strains better suited to Scania.

## Early Strains

### (Table 2)

This trial group comprised eleven strains, of which, however, two (Harrie and Lindby) were of the later type. Ötofte Tidlig was the check variety here. In Table 2 it is possible to distinguish immediately a group of four strains which in almost all the six cuts of the first and second year leys were more or

## TABLE 2

Yield in tons green mass per ha. of Ötofte early together with differences between it and other early strains

(Rel. No. : Ötofte early=100.

| STRAIN | FIRST CUT | | | | SECOND CUT | | | | THIRD CUT | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of trials | Ötofte t/ha | Difference t/ha | Rel. No. | No. of trials | Ötofte t/ha | Difference t/ha | Rel. No. | No. of trials | Ötofte t/ha | Difference t/ha | Rel. No. |
| **FIRST YEAR LEY** | | | | | | | | | | | | |
| Essi | 20 | 25·02 | —1·51** | 94·0 | 20 | 13·08 | +1·65** | 112·6 | 21 | 10·85 | +0·25 | 102·3 |
| Lofa | 14 | 27·76 | —2·68** | 90·3 | 14 | 13·54 | +2·51*** | 118·5 | 15 | 11·04 | +0.56 | 105·1 |
| Tystofte No. 40 | 10 | 24·78 | +0·14 | 100·6 | 10 | 12·38 | +1·00* | 108·1 | 10 | 12·63 | +0·43 | 103·4 |
| Fionia | 8 | 26·51 | +1·38* | 105·2 | 8 | 14·48 | +0·51 | 103·5 | 9 | 7·77 | +0·27 | 103·5 |
| Hinderupgaard | 8 | 26·51 | +1·15* | 104·3 | 8 | 14·48 | —0·03 | 99·8 | 9 | 7·77 | +0·15 | 101·9 |
| Silesian, Polish | 25 | 24·72 | —3·98*** | 83·9 | 25 | 13·02 | +0·14 | 101·1 | 26 | 9·13 | —0·44* | 95·2 |
| Silesian, Bohemian | 19 | 23·08 | —4·96*** | 78·5 | 19 | 13·25 | —0·65* | 95·1 | 20 | 7·38 | —0·48** | 93·5 |
| Russian, Svalöf | 17 | 23·90 | —3·37*** | 85·9 | 17 | 12·34 | +0·01 | 100·1 | 17 | 9·85 | —0·71* | 92·8 |
| Binga | 5 | 23·60 | —4·54*** | 80·8 | 5 | 11·16 | +0·72 | 106·5 | 5 | 2·48 | —0·36* | 85·5 |
| Lindby 30/315 | 6 | 18·08 | —1·60 | 91·2 | 6 | 13·37 | —2·25*** | 83·2 | 6 | 10·38 | —1·53** | 85·3 |
| Harrie | 25 | 24·72 | +3·26** | 113·2 | 25 | 13·02 | —3·96** | 69·6 | 26 | 9·13 | —0·64 | 93·0 |
| **SECOND YEAR LEY** | | | | | | | | | | | | |
| Essi | 14 | 14·76 | —2·47*** | 83·3 | 12 | 8·33 | +1·05 | 112·6 | 12 | 2·28 | —0·03 | 98·7 |
| Lofa | 11 | 15·73 | —1·31 | 91·7 | 11 | 8·84 | +2·41* | 127·3 | 11 | 2·49 | +0·51 | 120·5 |
| Tystofte No. 40 | 5 | 18·00 | —1·30* | 92·8 | 5 | 9·38 | +0·82 | 108·7 | 5 | 2·68 | —0·40 | 85·1 |
| Fionia | 7 | 13·20 | +0·97 | 107·3 | 7 | 7·66 | +0·40 | 105·2 | 7 | 2·00 | —0·06 | 97·0 |
| Hinderupgaard | 7 | 13·20 | +0·69 | 105·2 | 7 | 7·66 | +0·41 | 105·4 | 7 | 2·00 | —0·09 | 95·5 |
| Silesian, Polish | 18 | 14·86 | —3·76*** | 74·7 | 16 | 8·81 | —0·29 | 96·7 | 16 | 3·32 | —1·13 | 66·0 |
| Silesian, Bohemian | 14 | 14·76 | —4·97*** | 66·3 | 12 | 8·33 | —1·39 | 83·3 | 12 | 2·28 | —0·93* | 59·2 |
| Russian, Svalöf | 11 | 15·73 | —3·24*** | 79·4 | 9 | 8·84 | —0·49 | 94·5 | 9 | 2·49 | —1·29 | 48·2 |
| Binga | 4 | 15·20 | —1·98 | 87·0 | 4 | 10·25 | —0·50 | 95·1 | 4 | 6·43 | —0·98 | 84·8 |
| Lindby 30/315 | 3 | 11·23 | +4·60 | 141·0 | 1 | 2·70 | —1·20 | 55·6 | — | — | — | — |
| Harrie | 18 | 14·86 | +5·05*** | 134·0 | 16 | 8·81 | —1·84** | 79·1 | 16 | 3·32 | +0·24 | 107·2 |

less certainly inferior to the check strain. These strains constitute all the tested varieties of so-called Silesian red clover, namely, early clover from Poland, Bohemia, and Russia and the grown-on Silesian clover from Binga. Their inferiority is so striking that the trials can be said to have shown clearly and distinctly that Silesian red clover is particularly unsuitable even for the Scanian lowlands. It was possible to demonstrate this earlier both at Svalöf and Weibullsholm. The Lindby strain is almost equally poor in the 1-year ley, but has not been sufficiently tested in 2-year leys.

Essi, Lofa, and Tystofte No. 40 resemble one another in that in the first cut of the year in general they give a lower yield than the check strain, in the second cut their yield is higher than that of the latter and in the third cut approximately equal to it. In their total yield for the year, they are about equal to Ötofte Tidlig. None of them can with certainty be said to be superior to any one of the others.

Fionia and Hinderupgaard have not been tested so thoroughly, but both in the first and second-year ley they appear to be slightly superior to Ötofte Tidlig. The superiority lies mainly in the first cuts of each year.

The results with early strains of red clover can be summarized in the following way. Imported or grown-on Silesian red clover has given decidedly the lowest yield. In the first-year ley the Lindby strain was almost equal to it. Tystofte No. 40, Lofa and Essi give a relatively low first cut but have very good aftergrowth, while Ötofte Tidlig, Fionia and Hinderupgaard give a large first cut and medium aftermath. All these six strains have given very similar total yields.

### Comparison between Early and Medium-late Strains

As representative of the early strains Ötofte Tidlig has been chosen and of the medium-late the Harrie strain (see Table 2). When harvested three times a year, Harrie gives certainly a higher yield in the first cut of both first- and second-year leys than Ötofte Tidlig but also equally certainly a lower yield in the second cut. In the first-year ley its total yield is slightly but not certainly lower than that of Ötofte, but in the second-year ley it is quite certainly superior owing to greater persistency. Time of cutting trials at Svalöf and elsewhere have, however, shown that if the first cut be taken slightly earlier than was done in these trials, the medium-late strains give a somewhat larger first cut than the early ones, are equal to the latter in the second cut, and almost equal to them in the aftermath cut. If early clover is sown (the wisdom of doing so owing to the greater uncertainty and poorer persistency of such clover admits of argument) it should be used only in leys intended to be harvested for one year. If, however, an early clover strain is chosen, it is above all well to obtain better aftermath, and then Tystofte No. 40, Lofa and Essi are the best strains, but Ötofte Tidlig, Fionia and Hinderupgaard can also be recommended.

* * * *

The address was followed by a discussion.

*Dr. Sam. Nordfelt* remarked that he had noticed particularly that Dr. Nilsson-Leissner in his interesting address stated that he had investigated the behaviour of the various strains in different areas. Some varieties from central Sweden were clearly inferior down in Scania. It would be of interest to practical men and growers in central Sweden if tests were conducted to determine which varieties are most suitable up in that region. Experts in the area had also drawn his attention to the matter.

*Dr. Nilsson-Leissner* stated that trials with different strains were carried out at the Seed Association's branch-stations. In general in the trials the best strains from the respective branch station's own area had surpassed Scanian strains. Where clover stem rot was present to a considerable extent, it might, however, happen that the Scanian varieties particularly resistant to that disease, Mercury and Resistant, would give better yields than the local strain in question. For the rest the speaker pointed out that the majority of local strains gave top yields only within strictly limited areas, but that some exceptions occurred, as, for example, the Ultuna strain, which in extensive areas in Svealand, south Norrland and north Götaland was very high-yielding.

*Dr. A. Elofson* stressed the value of local strains particularly because they gave a reliable yield, and stated that the officials of the Swedish Grassland Society had always warned possessors of old local strains not to exchange these for others, before adequate experience had been gained as to the cultivation value of the latter. As seed of Scanian strains grown in Scania is frequently not sufficient to satisfy the province's own requirements of clover seed, he was strongly of the opinion that it was better to meet the need by central Swedish seed of strains indigenous to that part of the country than to import foreign seed. It was important that seed growers in central Sweden should receive definite information in regard to this matter, so that they might not incur the risk of growing seed, which later it might be impossible to sell in the more southerly parts of the country.

*E. Waller* pointed out that stem rot and the clover eelworm had become increasingly general in Västergötland, and that where these attacks occurred the resistant varieties from the Scanian plant breeding stations possessed a decided advantage over even the best Västergötland strain, that from Hassle-Säby. The Seed Growers' Association of the county of Skaraborg has initiated a series of trials in which are included only Mercury, Resistant, and the Hassle-Säby strain.

# SEASONAL VARIATIONS IN THE GROWTH OF PASTURES

G. Rappe

In connexion with observations regarding variations in the supply of pasture during the summer, I noticed how greatly the pasture plants differed in their mode of distribution of production during the different parts of the summer under varying environmental conditions, and it seemed to me probable that an investigation of questions relevant to this matter would furnish information of interest.

I therefore organized a series of experiments to elucidate the matter, and I now give a brief summary of the nature of the investigations and of some of the results obtained with reference to the production of dry matter. A detailed report will be included in the series "Svenska Vall- och Mosskulturföreningens Meddelanden."

Sixty plots with varying levels of subsoil water were laid down at the Experiment Station of the Institution of the Swedish Moorland Cultivation Association at Jönköping. For the investigation three soils were selected which differed from one another as widely as possible : a moraine soil of good quality from the moraine area 2 miles north-east of Tenhult, together with a humus-rich nitrogenous peat soil and a humus-deficient sphagnum peat soil from the same neighbourhood. Each of these soils was distributed among twenty plots ; these were divided into lots of four with a subsoil water level of 20 cm., 40 cm., 60 cm., 80 cm. and 110 cm. respectively. All the sixty plots were manured and limed normally and were sown with an appropriate mixture of pasture plants in the spring of 1935. During the summer of 1935 the stand was allowed to grow freely, with only two cuts, and notes were made as to uniformity of stand on the different plots. During the years 1936, 1937 and 1938, cutting was carried out on all the plots in every third week before July 1 and every fourth week after that date. After each cut the ground was trampled to imitate treading by animals.

Simultaneously, corresponding experiments were set up, partly at Flahult in Småland, on mineral soil, which here was poor sandy soil, on nitrogenous peat soil and on sphagnum peat soil, and partly at Gisselås in Jämtland, on mineral soil (gravel soil) and bog soil.

The series of experiments at Flahult and Gisselås were harvested during the 5 years up to and including 1941. The Jönköping experiments had to be discontinued after 3 years when the Association removed from there.

All the plots at the three centres were manured each year with superphosphate and potash. Half of them received in addition annually 300 kg. calcium nitrate per ha. At Flahult and Gisselås the calcium nitrate was distributed equally to all the pasture crops ; in Jönköping one-half was applied in the spring, two-sixths about July 1 and one-sixth about September 1. During the last 2 years this system was applied to Flahult also. The nitrogenous manure was always sown immediately after a pasture cut, with the exception of the spring manuring.

Figures 1, 2 and 3 illustrate the daily production of dry matter. They represent three types selected from the 140 curves which appeared in the material. Figure 2 represents the most frequently occurring type at Flahult and in Jönköping; figure 1 represents a type which appeared on all three kinds of soil during one of the 5 years at Flahult, and figure 3 a type which occurred during three of the 5 years at Gisselås. In all the other years at Flahult and Gisselås, and every year at Jönköping, growth curves more or less suggestive of the type shown in figure 2 were exhibited.

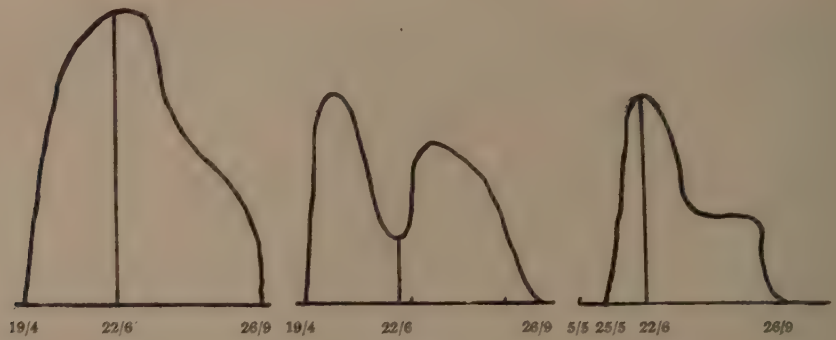


Fig. 1. Fig. 2. Fig. 3.

It was stated above that the most usual growth type was that which is represented in figure 2 and which appears during the years marked in the tables D +. It is characteristic of this type that a depression begins in the daily increase of dry matter in the period about midsummer, that daily growth starts rapidly in the spring and reaches its optimum at the end of May and beginning of June, declines more or less rapidly from immediately before the middle of June to reach its minimum immediately before midsummer, increases again subsequently, but as a rule without attaining the same dimensions as in the spring, and finally decreases gradually to the middle of October.

During one of the 5 years (1936) at Flahult (fig. 1) this depression did not occur, and the daily growth of the pasture plants showed during the whole vegetative period a gradual increase before the midsummer period and afterwards a gradual reduction. In addition during 1936 the depression did not appear with groundwater levels of 20 cm. and 40 cm. on sphagnum peat soil at Jönköping, but it occurred with groundwater at all levels on mineral soil and nitrogenous peat soil.

In 1936 at Flahult, the rainfall was particularly heavy during the months of April and May. In addition the temperature was lower than usual in April. Both these conditions prevailed also at Jönköping, but not in nearly so marked a degree as at Flahult.

On all the soils at Flahult in 1936 (but at Jönköping in that year only on sphagnum peat soil and with a high groundwater level) these climatic conditions probably resulted in the soil's remaining fairly saturated with moisture

even up to the surface during the whole of the early part of the summer and right on to midsummer. The marked moisture-retaining capacity of sphagnum peat soil probably brought it about in Jönköping that with high groundwater levels this soil remained more saturated with moisture than the other soils.

Tables 1 and 2 show the monthly precipitation and mean temperature from April to September at Jönköping, Flahult and Gisselås during the years the experiments were in progress. If the year exhibited a period of depression for the growth of dry matter in the midsummer period it is marked D +, if this was not the case D —.

TABLE 1. Precipitation mm.

| | | | April | May | June | July | August | Sept. | Total |
|---|---|---|---|---|---|---|---|---|---|
| Jönköping .. | 1936 | D + | 46 | 59 | 24 | 149 | 84 | 31 | 393 |
| | 1937 | D + | 24 | 43 | 60 | 36 | 20 | 92 | 275 |
| | 1938 | D + | 11 | 76 | 48 | 58 | 64 | 41 | 298 |
| Flahult .. | 1936 | D — | 64 | 93 | 50 | 171 | 89 | 47 | 514 |
| | 1937 | D + | 35 | 55 | 60 | 39 | 47 | 106 | 342 |
| | 1938 | D + | 16 | 87 | 77 | 79 | 82 | 50 | 391 |
| | 1939 | D + | 64 | 22 | 37 | 98 | 127 | 30 | 378 |
| | 1940 | D + | 26 | 21 | 114 | 104 | 86 | 105 | 456 |
| Gisselås .. | 1937 | D + | 13 | 52 | 50 | 61 | 18 | 111 | 305 |
| | 1938 | D + | 6 | 65 | 104 | 82 | 20 | 53 | 330 |
| | 1939 | D — | 29 | 12 | 51 | 108 | 19 | 43 | 262 |
| | 1940 | D — | 9 | 11 | 18 | 56 | 127 | 55 | 276 |
| | 1941 | D — | 3 | 0 | 93 | 77 | 150 | 59 | 382 |

TABLE 2. Mean Temperature

| | | | April | May | June | July | August | Sept. |
|---|---|---|---|---|---|---|---|---|
| Jönköping .. | 1936 | D + | 3·4 | 9·3 | 16·0 | 16·9 | 15·9 | 10·4 |
| | 1937 | D + | 5·9 | 11·8 | 14·7 | 17·4 | 17·5 | 12·4 |
| | 1938 | D + | 5·5 | 9·3 | 14·2 | 16·4 | 17·4 | 13·2 |
| Flahult .. | 1936 | D — | 2·5 | 8·7 | 15·5 | 15·7 | 14·7 | 8·8 |
| .. | 1937 | D + | 5·2 | 11·1 | 13·4 | 16·4 | 15·8 | 10·8 |
| | 1938 | D + | 4·1 | 8·1 | 12·5 | 15·2 | 15·7 | 11·6 |
| | 1939 | D + | 4·3 | 8·7 | 14·6 | 15·3 | 16·4 | 9·8 |
| | 1940 | D + | 1·7 | 9·3 | 15·1 | 14·8 | 12·3 | 8·6 |
| Gisselås .. | 1937 | D + | 2·7 | 9·6 | 13·2 | 17·2 | 14·8 | 7·4 |
| | 1938 | D + | 1·0 | 6·5 | 10·7 | 15·8 | 13·3 | 8·4 |
| | 1939 | D — | 0·2 | 5·7 | 10·5 | 15·2 | 14·6 | 6·9 |
| | 1940 | D — | —0·9 | 8·2 | 12·6 | 13·4 | 10·4 | 5·8 |
| | 1941 | D — | —1·9 | 5·5 | 9·8 | 16·8 | 10·6 | 6·9 |

The depression did not occur when the soil was saturated with moisture during the earlier half of the vegetative period. The material now under consideration cannot be used to explain how spring soil saturated with moisture (1936) affected the vegetation differently from spring soil containing less moisture (1937, 1938, 1939, 1940), but that such was the case is sufficiently clear. Possibly during normal years the deficient supply of moisture in the soil is the main factor which checks the repeated efforts of the pasture plants

to put out fertile shoots, so that, for example, after two or three attempts at such shoot formation have been checked by grazing, the effort is discontinued owing to lack of moisture and a period of depression sets in before the preparation for vegetative overwintering is begun through the formation of shoots not designed for seed setting. During the years when moisture is adequate the repeated attempts to form fertile shoots are continued so long that they pass over directly, without an intervening period of depression, into shoot formation in the height of the summer and in the autumn designed for vegetative overwintering. The appearance or non-appearance of the depression is then probably connected with biological conditions in the pasture plants themselves. It is, however, also conceivable that the depression is connected with microbiological conditions in the soil, which assume a different aspect during years when the weather in the spring and early part of the summer is very wet and during years with normal moisture at that time of the year. An interaction of the factors mentioned is not precluded, but all the reflexions relevant to this matter are merely hypotheses, which future investigations will confirm or prove incorrect. It merely remains to observe that depression set in as a rule in these experiments but did not appear during a year with a wet spring.

During 3 of the 5 years at Gisselås (1939, 1940 and 1941), depression also did not occur during midsummer. In these three years, growth started late (May 21, May 18 and May 25, respectively), while during the other two years (1937 and 1938) it began early (April 25 and May 2, respectively). The former occurrence is usual at Gisselås. Melting of the snow began very late during the three years 1939, 1940 and 1941. Growth did not start until the end of May, and both mineral soil and bog soil were probably saturated with winter moisture during the whole month of June, thus an occurrence similar to that at Flahult in 1936. This seems to indicate that the depression is a phenomenon which appears with a comparatively long vegetative period but does not appear when this is curtailed—connected with the moisture conditions in the soil before the midsummer period. (Compare type of vegetation, fig. 3.)

Of the detailed observations which it has been possible to make on the relevant material, the following may be cited.

The depression is more pronounced on all the soils where nitrogenous manuring was carried out than where nitrogen was not applied, and more pronounced the greater the effect of the nitrogen. This appears particularly clearly on the nutrient-deficient sphagnum peat soil.

The depression is decidedly greater when the subsoil water is at a deep level than when it is at a shallow level. On the low-yielding sphagnum peat soil no considerable depression appeared—when nitrogenous manuring had not been carried out—until the level of the subsoil water had fallen to 80–110 cm. below the surface of the ground.

In agreement with a previously enunciated observation, it may therefore be stated : when the subsoil water is maintained permanently in a definite position, possibly not even the heaviest precipitation can cause the soil to be

completely saturated with moisture. Only when this can happen (Flahult 1936) does the depression fail to appear completely with vigorous production. The normal occurrence appears on the contrary to be that depression sets in and that it becomes more pronounced the more luxuriant the vegetation is in the early part of the summer, that is to say, before the depression.

When depression occurs, it sets in normally at midsummer and in addition only during markedly dry periods at another part of the growing period. The midsummer depression on the contrary does not appear to require to be connected with any dry period.

In the latitudes of Jönköping and Flahult on the average about two-fifths of the vegetative period (64 days) falls before the zenith of the depression and about three-fifths of the growing period (96 days) after it. Normally the highest daily growth in the pasture stand begins some weeks before the depression.

At Gisselås the case is different. Here on the average only about one-third of the vegetative period (48 days) falls before the sun has reached its highest position (June 22) and approximately two-thirds (96 days) after that time. Only during particularly early years at Gisselås does the soil become so warm that the highest daily growth can begin before the time mentioned—but when that happens, the depression also sets in exactly as at Jönköping and Flahult. Most years at Gisselås, however, growth starts so late that the highest daily growth is not attained before the sun's highest position has been reached. The midsummer depression does not then occur and is replaced instead by an optimum condition for daily growth, but this daily growth declines subsequently during the whole remaining portion of the vegetative period without showing any fresh increase, as normally happens after the midsummer depression in the years when this occurs.

The highest daily growth may probably not occur before the soil has been adequately ventilated after being saturated with water in the spring. Possibly this holds good "concerning the highest daily growth" also for the year 1936 at Flahult. The moisture and the gradual warming of the soil act as a stimulus during the early part of the summer to more and more daily growth. The optimum has not set in before midsummer has been passed and the depression never has an opportunity of making its appearance.

Whatever the explanation may be, the fact remains that something peculiar in regard to the behaviour of daily growth occurred as a rule at midsummer in this material. Data on the relation between production before and after June 23 may be cited here.

The higher the level of the subsoil water, the larger is the share of the total pasture production which is obtained in the later part of the summer. This is most clear with nitrogenous peat soil and sphagnum peat soil. The average daily production in the later part of the summer is also higher in comparison with the average daily production in the early part of the summer, and the highest daily production after midsummer is greater in comparison with the highest daily production before midsummer.

Finally we shall cite some practical conditions in agriculture, which the experimental results under consideration may help to elucidate. The results require confirmation by further experiments and practical observations. New series of experiments have also been initiated this year (1943) in Uppland and in North Bothnia. If it should prove that the experimental results hold true with this continued testing, they should be able to furnish useful information for future work in this connexion.

By maintaining a fairly high groundwater level, it is possible to achieve considerably improved relative growth in a pasture ley at the height of and in the later part of the summer in comparison with the growth before midsummer, which very frequently is more adequate for requirements than is the pasture in the later part of the summer. A larger part of the total production is postponed until the height and later part of the summer.

The possibilities of attaining this advantage appear to be greater on nitrogenous bog soil and sphagnum peat soil than on mineral soil. The inconveniences due to the trampling of the animals when the subsoil water is at a shallow level are, however, very great, and greatest on the peat soils. But peat soils are more frequently than mineral soils so situated that the level of the subsoil water can to a certain extent be regulated by means of damming up. The ground is then carefully drained, for example, to a depth of 1 metre, and the water allowed to flow off normally in the spring, whereby the surface of the soil is consolidated to withstand the treading of the animals. Damming up is effected afterwards, when a supply of water is available. With damming up one should not, however, wait until the ground has become too dry, if a good effect is to be achieved. Questions connected with this matter call for investigation, and experiments have been initiated on the reclaimed bogs of Gotland.

The experiments at Gisselås suggest that there it should be possible to achieve a corresponding effect by nitrogenous manuring, in any case during years when growth begins early and total production is therefore comparatively large. During late years the application of nitrogen is necessary in order to obtain anything approaching good yields. Neither at Flahult nor Jönköping, however, do the experiments show the same trend, but the case may very well be different in the north.

It appears to be an urgent problem to try to counteract the depression around the midsummer period as far as this is possible. In practice this is done by saving the surplus of the pasture which grows luxuriantly in the spring through postponing the grazing of the already adult folds until the midsummer period, after they have for the first time been grazed earlier in the spring. Thus during the latter half of June, grazing takes place of pasture plants which for the most part have grown up during top production in May.

When these are finally grazed at the beginning of July, it is, however, frequently found that the folds which were previously grazed at the beginning of June have made particularly poor aftergrowth. They have had only the month of June in which to produce aftermath and during its latter half the depression occurs. Gradually, as August approaches, the herbage becomes

more luxuriant and in August and September good grazing is again obtained. It is, however, not always possible to reserve a sufficient number of spring-grown folds in order to obtain good grazing in the whole of July, as the herbage then readily withers or is otherwise reduced in value while awaiting grazing.

The experiments indicate that a higher groundwater level (damming up) might reduce the depression slightly. Even if this should to some extent be the case, the reduction of the depression is not so great as alone to justify damming up. This measure is justified, however, by its effect in producing a higher yield during the later part of the summer on the pastures. Prior to damming up, the land must have been thoroughly well drained.

Nitrogenous manuring as carried out in the experiment (the same for each pasture cut, or in Jönköping, three-sixths in the spring, two-sixths about July 1 and one-sixth about September 1) did not reduce but increased the depression, particularly where nitrogenous manuring had a greater effect. But this does not necessarily mean that appropriate nitrogenous manuring could not counteract the depression. Experiments should be conducted to determine how the nitrogen should be applied (and in what quantities) to attain this object. In the first place the effect of incremental amounts of nitrogen, applied at the beginning of June, should be tested. The extensive experimental work conducted by the Society under the direction of Dr. Giöbel has shown that very large amounts of nitrogen given in repeated doses after each grazing increase production considerably. But possibly the large doses applied at a certain time of the year—June 1 to 10—might prove to have a particularly marked effect.

* * * *

In the discussion which followed *Dr. Elofson* pointed out that when greater quantities of nitrogen are applied, the yield is usually larger.

Since 1927 experiments have been conducted with grazing animals on different farms, and it has been established that where the pasture is badly grazed it is also badly drained. It has been most difficult to induce the animals to graze the herbage thoroughly where the groundwater is at a high level.

*O. Djurle* stated that the experiments showed that the yield from the pastures is decidedly better and more uniform where the groundwater is at a higher level. It is not to be concluded from these experiments, however, that drainage can be neglected and above all on Sweden's fen and peat soils. These experiments and practical experience have shown that to obtain the largest yield the ditches should be kept clear to a depth of 60 to 80 cm. This has an influence also on the quality of the fodder; the animals graze better on dry ground. To the extent that one can raise the groundwater level during the early part of the summer this should be done, but care should be taken not to dam the water in the spring, because then the pasture readily dries up in the early part of the summer.

*Dr. Rappe* emphasized the fact that the midsummer depression was not due to deficient precipitation, and quoted some rainfall data to illustrate this. During three of the four years when the experiments at Flahult exhibited

midsummer depression, precipitation in June had varied between 37 and 77 mm. and on the whole was as high as during May and July; in the fourth year with midsummer depression, the rainfall in June amounted to 114 mm. In the year when the midsummer depression did not occur, precipitation in June was only 50 mm.

## TRIALS WITH TIMOTHY

G. JULÉN

Timothy is undoubtedly the most important of the hay grasses employed in Sweden. It is grown throughout the whole country from Scania to the most northerly part of Norrland, and in central and north Sweden it is practically the only grass in hay ley mixtures. It was therefore natural that both breeding and experimental work with this grass should have been initiated at an early date by the Swedish plant breeding stations. Breeding work was begun by the Swedish Seed Association in 1904, and five years later the first comparative trial was laid out at Svalöf, and has been repeated each year subsequently. At the branch stations of the Association, timothy trials have been set up every year during practically the whole time that these various stations have been functioning. Owing to the relatively large number of trials which have been carried out in this way, the summated results give a good conspectus of the cultivation value of the different varieties in different parts of the country.

Before dealing with the value of the different varieties relative to one another, it may be of interest to say something about the yielding capacity of timothy. In trials at Svalöf the yield of Ultuna timothy—as the average for 30 years—the variety has been included in trials since 1902—has been about 14 tons green mass per ha. in the first cut, and about 19 tons if the aftermath be included. The yield is slightly higher in Norrland. Thus at the branch station in Luleå, Ultuna timothy on the average has given fully 19 tons in the first cut alone. The aftermath, which is the weak point with this grass, is always relatively small. In this connexion, it might be of interest to institute a comparison between the aftermath at the present time and about 20 to 30 years ago. At that time timothy was harvested in the trials—as it was in practical agriculture—at a relatively advanced stage, while nowadays it is cut immediately after panicle emergence. During the period 1912–20 the aftermath at Svalöf varied between 2 and 7 per cent of the total crop, while during the period 1936–40 it varied between 23 and 36 per cent. The total yield during the two periods was approximately equal in size. With the knowledge we now possess about the changes in the nutritive value of grass during development, one realizes what importance earlier cutting must have when it is a question of obtaining as high a yield of digestible nutrients as possible.

The strains which were first included in the comparative trials both at Svalöf and at the branch stations were, in addition to ordinary commercial seed and some breeding material, local strains from different parts of the country. The number of such local strains which had been developed in the course of time was very large when the work of breeding was begun. During the last few decades they have, however, become progressively fewer owing in part to their having been surpassed by improved varieties and in part to the fact that growers have not kept the strains pure, but mixed them with purchased seed when their own seed was in short supply. Consequently, the number of strains which can rightly be designated as local strains is now very small. As regards timothy, these local strains have not been as important as in the case of red clover, because timothy is very much less sensitive to external factors than red clover. The assortment of bred strains which now exists is also sufficient to enable suitable cultivation material to be obtained in all parts of the country.

Fig. 1. Yield of different varieties of timothy in trials at Svalöf

The accompanying diagrams (Figs. 1 and 2) show the relative value of the most important strains of timothy according to the experimental results which have been obtained at the different centres. Only the best varieties available on the market are included, namely, the Svalöf varieties, Gloria, Bore I and Bottnia, Kämpe II from Weibullsholm and Holmberg's Svea. Two new improved varieties have also been included, Bore II and Sv 0812. It would have been desirable also to procure a comparison with ordinary commercial seed, but as this varies so greatly in quality it is impossible to carry out a reliable comparison. The general verdict is, however, that the ordinary commercial seed gives a poorer yield than the bred varieties, and frequently the differences are quite considerable.

In Fig. 1 both the first and second cut at Svalöf are shown. The black columns represent the first cut and the stippled upper portions the aftermath.

The comparison is made between the summated yield in the first and second-year ley. On comparing the different strains with the old variety Gloria, it is found that Bore I and Kämpe II have given approximately the same yield as that variety, while Bottnia and Svea have been poorer, and Bore II and

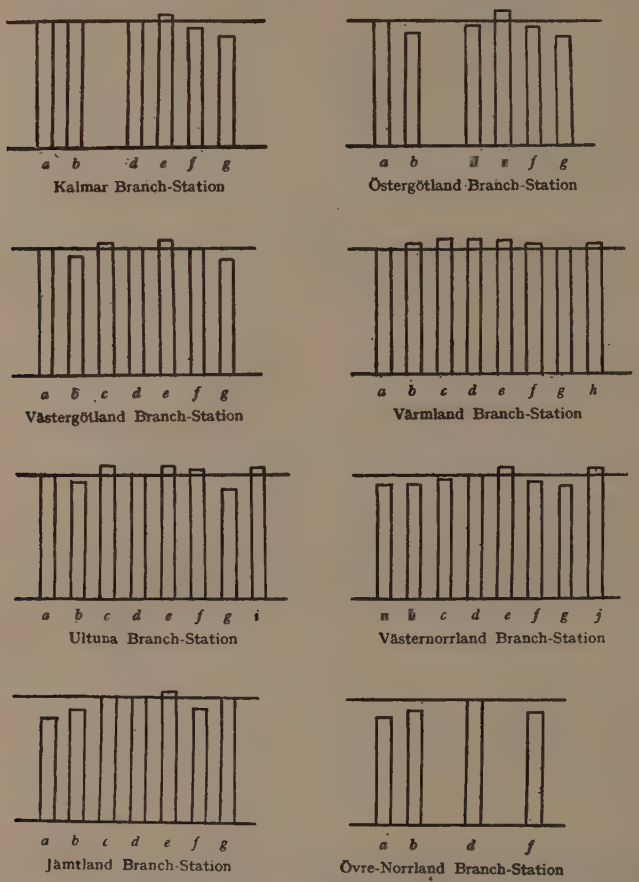
a b d e f g
Kalmar Branch-Station
a b f g
Östergötland Branch-Station
a b c d e f g
Västergötland Branch-Station
a b c d e f g h
Värmland Branch-Station
a b c d e f g i
Ultuna Branch-Station
b c d e f g j
Västernorrland Branch-Station
a b c d e f g
Jämtland Branch-Station
a b d f
Övre-Norrland Branch-Station

**Fig. 2. Yield of different varieties of timothy at the branch-stations of the Swedish Seed Association.**

Key to columns :—

| | | |
|---|---|---|
| *a* = Gloria | *e* = Sv. 0812 | *h* = Varpnäs |
| *b* = Bore I | *f* = Kämpe II | *i* = Gimo |
| *c* = Bore II | *g* = Svea | *j* = Bollsta |
| *d* = Bottnia | | |

Sv 0812 have been superior in yield. Gloria and Kämpe II are both intended more particularly for south and central Sweden, and they are almost equal under these conditions. One year the one variety is slightly superior to the other, in another year the other variety gives a slightly higher yield. The case is somewhat different where Bore I is concerned. This variety was bred at the

Värmland Branch Station and was intended for the Bergslag region, but it has been found to give a satisfactory yield also outside this area. Down in Scania, however, it generally gives a slightly poorer first cut than Gloria. That in the comparison it approximates so closely to Gloria is due to a great extent to the results obtained in 1941 and 1942, when Bore owing to its greater winter hardiness suffered less from the severe winters than Gloria. Bore I has, however, the best aftermath of all the varieties of timothy. The fact that Bottnia, which is a typical Norrland strain, has not been able to compete with the south-Swedish strains is not likely to cause surprise. The aftergrowth of this variety is very poor, a general characteristic of Norrland strains.

If we examine the results from the different branch stations, we find almost the same order among the varieties at all the experiment centres in Götaland and Ultuna, with the exception that Bore I is slightly poorer in Östergötland and Västergötland ; at those centres the experiments had to be ploughed up after the severe winters of 1941 and 1942, and the good winter hardiness of the variety was therefore not reflected equally in the experimental results obtained there and in those at Svalöf. At the Värmland Branch Station, however, Bore I and Bottnia begin to advance into the front rank, while Gloria and Kämpe II fall back, and this course of development becomes more marked as one progresses northwards. It may be well in this connexion to point out the particularly small differences between the varieties at the Värmland Branch Station. As a matter of fact, the results from year to year vary here more than at any other centre. This is probably due to the fact that the climate occupies a position exactly intermediate between that of South Sweden and Norrland so that in one year the good qualities of the one variety and in another year those of the other variety determine the result. It will generally be advisable in these regions to use such a variety as Bore I which has been found here to give a very uniform and reliable yield, as well as the local strain Varpnäs, which was also included in the experiments of the Värmland Branch Station. At the Norrland branch stations Bottnia is undoubtedly the best of the improved strains which have been put on the market, but in Västernorrland it has been surpassed by the local strain Bollsta.

The two new strains, Bore II and Sv 0812, which were included in the collation of experiments appear to be promising. Bore II is a selection from Bore I, and it has given better results than both Gloria and Bore I at all the experiment stations where it has been tested. If the aftermath is also taken into account, it has surpassed Bottnia up to Ångermanland and Jämtland. Sv 0812 was bred at Svalöf. It is interesting from the point of view of plant breeding inasmuch as it originates from a self-fertilized plant controlled for two generations. It has given particularly good results at all the experiment centres where it has been tested. As is seen from the diagram, it occupies a leading position everywhere, in some places surpassing the other varieties considerably. It is surprising that a variety produced down in Scania gives such good results up in central Norrland. In Ångermanland it was 10 per cent better than Bottnia even in the third-year ley, which shows that its winter hardiness is quite satisfactory. It has been tested only once in Luleå, when it was found to have one weakness—it is susceptible to *Sclerotinia borealis*,

a fungus disease which may be very troublesome on grasses in Norrland. If this variety fulfils in practice the promise it has given in experiments, it will constitute a very good universal variety for the whole of Svealand and Götaland and at least the southern half of Norrland.

The object of this paper has been to show that in choosing seed for sowing leys, the question of selection is not a matter of indifference. The additional cost incurred by choosing good seed of a suitable variety is remunerative. In this connexion I would also emphasize the desirability of conducting a larger number of varietal trials with meadow plants than has been done hitherto. In local experimental work the meadow plants have been allotted a very subordinate position, largely as the result of the lack of economic possibilities for conducting trials. The experiments which have been carried out under the direction of the Seed Association and which have been briefly reported here were all laid out on mineral soils. The experiments conducted by Lundblad on peat soils indicate that even in the Småland uplands on such soils varieties should be employed which generally are characterized as Norrland varieties.

## THE CAROTENE CONTENT OF FORAGE PLANTS

N. Olsson

The content of protective nutrient substances in home-produced fodder is of great importance for the health and productive capacity of domestic animals, while at the same time the percentage of these substances in the animal products and the value of the latter as food are in a high degree determined by that content. Knowledge of the content of vitamins and other protective nutrients in fodder plants is, however, very incomplete, and investigation is necessary in this sphere. The grassland cultivation and animal husbandry sections of the Nordiske Jordbrugsforskeres Forening have, therefore, taken the initiative for the setting-up of investigations into the quality of home-produced fodder, with special reference to its content of protective nutrient substances. As a result, investigations of this kind have been begun by the Swedish Seed Association at Svalöf and the branch stations, at the Agricultural College, Ultuna, and at the Research Laboratory in Copenhagen.

### I. Investigations on the Carotene Content of Meadow Plants

As the carotene in plants constitutes the most important source of supply of vitamin A for man and animal, the work comprised mainly studies on the variation in the proportion of carotene in different species and varieties of plants, depending on the stage of development, time of year, manuring, etc. Further, the keeping quality of the carotene in green fodder with different methods of conservation was investigated, also the resorption of the carotene in the intestinal canal of the animal.

## Investigations conducted in Denmark

The first results of these investigations were reported by Lund (*Aage Lund*: Investigations of the carotene content of fodder plants. *Nordisk Jordbrugsforskning*, Heft 7, 1942), who investigated the carotene content in some of Sweden's most important meadow plants, namely, ryegrass (*Lolium*), timothy (*Phleum pratense*), cocksfoot (*Dactylis glomerata*), meadow fescue (*Festuca pratensis*), red clover (*Trifolium pratense*), and lucerne (*Medicago sativa*), when some strains of the different species were also compared. The results of an investigation conducted in 1941 show that the ordinary meadow grasses in the pasture stage contained between 180 and 470 mg. active carotene per kg. dry matter, while in the hay stage at the first cut they contained only between 100 and 240 mg. per kg. dry matter. In the aftermath, the carotene content of the grasses was consistently higher than in the first cut and varied between 185 and 345 mg. per kg. dry matter.

### Table 1

The connexion between carotene content and other characters in *Dactylis glomerata* and *Lolium* in different stages of development.

Investigation conducted by Dr. Aage Lund, 1942.

| Date of cutting | Height of stand (in cm.) | Dry matter per cent | Mg. carotene per kg. dry matter | Crude protein in % of dry matter | Pure protein in % of dry matter |
|---|---|---|---|---|---|
| | | *DACTYLIS GLOMERATA* | | | |
| 13/5 .. | 16 | 21·7 | 363 | 20·7 | 18·4 |
| 26/5 .. | 35 | 24·2 | 212 | 12·0 | 10·8 |
| 8/6 .. | 80 | 27·3 | 170 | 9·2 | 8·3 |
| 18/6 .. | 95 | 30·4 | 101 | 6·9 | 6·0 |
| 30/6 .. | 105 | 37·6 | 92 | 5·4 | 4·5 |
| 7/7 .. | 110 | 34·3 | 88 | 4·9 | 4·3 |
| | | *LOLIUM* | | | |
| 13/5 .. | 10 | 27·5 | 288 | 16·5 | 13·7 |
| 27/5 .. | 25 | 29·0 | 181 | 10·0 | 9·2 |
| 8/6 .. | 25 | 26·5 | 199 | 9·9 | 8·8 |
| 18/6 .. | 35 | 31·8 | 100 | 6·2 | 5·6 |
| 30/6 .. | 55 | 33·7 | 91 | 6·1 | 5·7 |
| 7/7 .. | 60 | 30·9 | 118 | 6·8 | 6·0 |

The carotene content of red clover was in the pasture stage approximately 325, in the first cut approximately 200, and in the aftermath 260 to 330 mg. per kg. dry matter ; the carotene content in lucerne was similar to that in red clover. It was not possible to determine any clear differences between the strains belonging to the same plant species investigated by Dr. Lund ; on the other hand distinct differences were found between certain plant species.

The carotene content in the sample cuts on the same plot taken successively during the vegetative period is of special interest. As an example, it may be stated that the carotene content in cocksfoot varied between 260

and 469 mg. carotene per kg. dry matter. This variation in all probability depended on the external conditions for development of the grasses, which *inter alia* may influence the ratio between the quantity of leaf and the quantity of stem in the plants. The larger the portion of the plant which is composed of leaf, the higher usually is its carotene content.

The results show that the differences between the carotene content of the different meadow plants may be very considerable. In the first hay cut, the carotene content of ryegrass, timothy, and meadow fescue was only approximately 100–120 mg. per kg. dry matter, while in cocksfoot it was about twice as high and almost comparable with the carotene content in red clover and lucerne.

The connexion between the stage of development of grasses at the time of cutting and their carotene content is shown further by an experiment which Dr. Lund conducted during 1942 with cocksfoot and ryegrass (see Table 1). The carotene and protein contents of grasses were reduced gradually as the dry matter increased. When cutting took place in an early stage (May 13) the carotene content was 300–400 mg. per kg. dry matter ; it fell, however, successively and in the stands which were cut as late as July 7 it was only 88 mg. in cocksfoot and 118 mg. in ryegrass per kg. dry matter.

### Effect of the Manuring on the Carotene Content of Meadow Plants

Lund conducted an investigation to determine whether potash manuring has any effect on the carotene content of ryegrass ; the doses of potash varied from 0 to 40 kg. No distinct difference could be determined between the carotene content of the grass harvested from the different plots ; it varied only between 55 and 57 mg. per kg. dry matter. In another experiment, however, Lund was able to determine a difference in the carotene content of grass as a result of differential manuring with potash, phosphoric acid, and nitrogen, and considers that this difference was due to dissimilarities in the botanical composition of the plant stand which were caused by the manuring.

## Investigations conducted in Sweden

Systematic investigations on the carotene content of meadow plants have also been initiated in Sweden ; a series of carotene determinations conducted during 1942 by Dr. Lindberg in the Cereal Laboratory of the Swedish Seed Association at Svalöf is of special interest. The investigation comprised lucerne, red and white clover, timothy, smooth-stalked meadow grass and perennial ryegrass, in which the carotene content was determined, firstly, in the pasture stage (4 cuts), and secondly, in different hay stages. The results are brought together in Table 2. In both the pasture and the hay stage the carotene content was throughout highest in white clover, slightly lower in red clover and lucerne, and lowest in the grasses. It is of special interest that the carotene content in the grasses in the pasture stage varied considerably from the one cut to the other : it was higher at the beginning

Table 2. The carotene content of some meadow plants in the pasture stage (4 cuts), in appropriate and late cutting stages, and also in aftermath.

Investigation carried out by Dr. Lindberg at Svalöf.

| | mg β-carotene per kg. dry matter | | | |
|---|---|---|---|---|
| Pasture stage. | 1st cut | 2nd cut | 3rd cut | 4th cut |
| *Medicago sativa* .. | 258 | 365 | 380 | 424 |
| *Trifolium pratense* .. | 462 | 362 | 391 | 301 |
| *Trifolium repens* .. | 538 | 395 | 463 | 595 |
| *Phleum pratense* .. | 369 | 222 | 231 | 308 |
| *Poa pratensis* .. | 347 | 192 | 211 | 230 |
| *Lolium perenne* .. | 214 | 147 | (425) | 244 |

| Hay stage. | Appropriate hay stage | Late hay stage | Aftermath |
|---|---|---|---|
| *Medicago sativa* .. | 322 | 246 | 310 |
| *Trifolium pratense* | 293 | 139 | 537 |
| *Trifolium repens* .. | 479 | 266 | 408 |
| *Phleum pratense* .. | 184 | 80 | 178 |
| *Poa pratensis* .. | 320 | 168 | 335 |
| *Lolium perenne* .. | 175 | 64 | 378 |

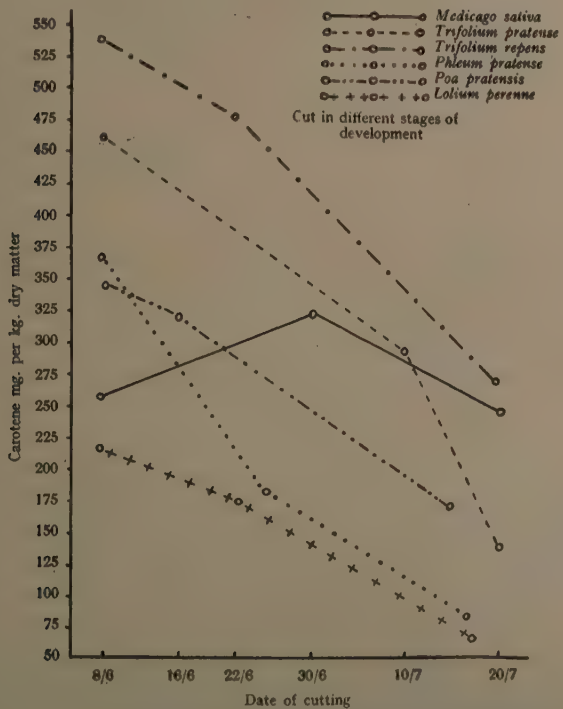


Fig. 1. Variation in the carotene content of some meadow plants depending on their stage of development, according to results obtained at Svalöf in 1942.

and end of the vegetative period than during the intermediate period, that is, in the height of the summer. Here as in the Danish investigations the time of year appears to have influenced the development of the plants and therewith their carotene content. The carotene content of all the meadow plants with the exception of lucerne fell with advance in development, as is shown by Fig. 1. It was probably accidental that lucerne in this case had a lower carotene content in the pasture stage than at the first cut.

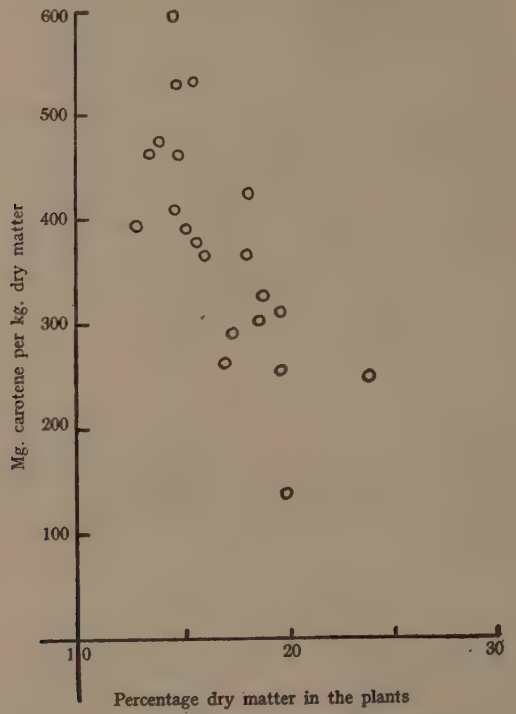


Fig. 2. Correlation between carotene content (mg. per kg. dry matter) and dry matter content in lucerne and in red and white clover. The observations represent different stages of development in the plants. Coefficient of correlation = —0·70 ± 0·11.

In a series of determinations of carotene in meadow plants conducted by Dr. Köhler at the Agricultural College, it was found that the larger the proportion of the plant which is composed of leaf, the higher is its carotene content. Separation of the plant mass was not carried out at Svalöf : in this material, however, the correlation between dry matter and carotene content was calculated, for legumes and grasses separately. For the first-mentioned group, that is, clover and lucerne, the coefficient of correlation was —0·70 ±0·11 (see Fig. 2) and for grasses —0·74 ±0·10. This negative correlation between the content of dry matter and the content of carotene in meadow plants has a certain interest. The higher the percentage of dry matter the plant contains, the larger is the portion of the latter which is composed of stem.

From this it is possible to conclude directly that the higher the percentage of dry matter in green meadow plants, the lower is their carotene content calculated per kg. dry matter. The same holds good for the protein content. It has also been determined that in the stages of development in which the meadow plants have a high protein content, they have also a high carotene content and *vice versa*. This fact is well illustrated by Dr. Lund (1942, see Table 1). The differences between the carotene content in the various meadow plants and the different cuts thereof thus depend to a great extent on the ratio between soft and hard tissues in the plants, and that in its turn depends on the time of year and also on the weather conditions which prevail during their development. This does not mean to say that differences in carotene content in the cells of the different meadow plants are devoid of, or are only of secondary, importance : at present too little is known about this matter. Before dealing with this problem it is, however, important to study carefully the external factors which may influence the carotene content of the plants.

### 2. Investigations on the Carotene Content of Root Crops

In the Cereal Laboratory of the Swedish Seed Association during the autumn of 1942, Dr. Lindberg investigated the carotene content of some varieties of roots, and found that tops of the root crops in general are rich in carotene, while the roots, with the exception of coloured carrots, have a low carotene content or are devoid of carotene. The results presented in Table 3 show *inter alia* that the carotene content in the tops and in the roots may vary within wide limits. Swede tops are rich in carotene, and in some varieties of yellow Swedish swedes they may contain up to 300 mg. per kg. dry matter, that is, as much as best quality pasture grass and clover in the pasture stage. Tops of other varieties of swedes had a slightly lower carotene content. These results are of great value and are an incentive to continued investigations in this sphere. Turnip tops contained 60 to 100, beet tops 80 to 120, and carrot tops 40 to 70 mg. carotene per kg. dry matter. The carotene content in the roots was : for swedes 0 to 10, turnips 10 to 30, beets 0, white carrots 20, yellow carrots 20 to 30, and red carrots approximately 375 mg. per kg. dry matter (about 45 mg. per kg. fresh carrots). According to Lund's investigations the carotene content in red carrots may vary from 300 to 1,400 mg. per kg. dry matter.

A special investigation has been conducted with sugar beet tops from different farms. The results show that sugar beet tops may contain between 40 and 115 mg. carotene per kg. dry matter, thus approximately as much as mangold tops (see Table 3) ; the variation with time of harvesting is not great, but it is possible to draw the conclusion that the carotene content is highest early in the autumn and falls slightly towards the end of the year.

### 3. Investigations on the Carotene Content of Kale

In the Cereal Laboratory of the Swedish Seed Association, Dr. Lindberg also investigated the carotene content of some varieties of kale, namely, Russian leafy kale, marrow stem kale, and green kale. Sampling was carried

out in the autumn of 1942. The results are presented in the following statement :—

| | Mg. carotene per kg. sample in leaves | stems |
|---|---|---|
| Russian leafy kale .. | 25 | 4 |
| Marrow stem kale .. | 31 | 2 |
| Green kale .. .. .. | 37 | 4 |

Table 3. Carotene content in roots, according to investigations conducted in the Cereal Laboratory of the Swedish Seed Association in 1942.

| Variety | Tops | | Roots | |
|---|---|---|---|---|
| | Dry matter | Mg. carotene per kg. dry matter | Dry matter | Mg. carotene per kg. dry matter |
| *Turnips.* | | | | |
| Bortfelder .. .. .. .. | 12·7 | 80 | 8·2 | 30 |
| Östersundom .. .. .. .. | 12·6 | 100 | 7·5 | 10 |
| Dales hybrid .. .. .. .. | 13·3 | 60 | 8·7 | 20 |
| Immuna .. .. .. .. .. | 13·2 | 61 | 9·5 | 20 |
| Majrova .. .. .. .. .. | 12·9 | 69 | 10·7 | 10 |
| *Beet.* | | | | |
| Barres halvlång .. .. .. .. | 10·3 | 87 | 13·8 | 0 |
| Rubra II .. .. .. .. .. | 12·4 | 87 | 15·8 | 0 |
| Röd Eckendorfer .. .. .. | 11·7 | 87 | 12·1 | 0 |
| Alfa .. .. .. .. .. | 11·5 | 118 | 14·8 | 0 |
| Sugar beet .. .. .. .. .. | 15·9 | 81 | 25·0 | 0 |
| *Carrots.* | | | | |
| Gul Champion, Svalöf .. .. .. | 18·0 | 60 | 10·6 | 20 |
| Gul Champion, Glostrup .. .. | 17·7 | 58 | 11·0 | 20 |
| Gul Champion, fam. 01 .. .. .. | 18·5 | 56 | 10·3 | 30 |
| Gul Champion, fam. 01 .. .. .. | 15·1 | 63 | 10·2 | 20 |
| James from stock seed .. .. .. | 17·1 | 40 | 11·8 | 379 |
| James from "post stock" seed .. .. | 17·4 | 40 | 12·4 | 375 |
| Supra vit Jätte .. .. .. .. | 15·9 | 71 | 12·5 | 20 |
| *Swedes.* | | | | |
| Bangholm .. .. .. .. | 15·5 | 232 | 11·0 | 8 |
| Yellow Swedish, "post stock" seed .. | 16·9 | 209 | 11·0 | 5 |
| Yellow Swedish, 07 .. .. .. | 17·1 | 256 | 10·8 | 5 |
| Yellow Swedish, 02 .. .. .. | 16·4 | 300 | 10·3 | 0 |
| Yellow Swedish, 02 .. .. .. | 16·1 | 254 | 10·5 | 10 |
| Yellow Swedish, line .. .. .. | 16·8 | 178 | 10·5 | 10 |
| Östergötland swede .. .. .. | 16·8 | 161 | 9·4 | 0 |

## 4. Investigations into the Durability of the Carotene in Green Fodder which had been ensiled according to different methods.

As the conserving of ley fodder is of great importance for the preservation of the carotene during storage, the Institute for Research in Animal Husbandry in connexion with its conservation experiments conducted by F. Jarl has also investigated the changes in the carotene content in silage during the period of storage. Thus, samples were taken of the fresh green fodder before conservation and also of the silage at different levels. The results obtained from the samples taken at Kungsängen during 1942–43 for carotene determination are brought together in Table 4.

Table 4. The carotene content in green fodder and silage according to investigations at the College of Agriculture in 1943.

Sampling was carried out by F. Jarl and carotene determinations by G. Köhler.

| | No. of Silo and Method | | | | | |
|---|---|---|---|---|---|---|
| | 1 AIV | 2 Formic acid | 3 Formic acid + 5% phosphoric acid | 4 Miko | 5 Miko without salt | 6 Cold fermentation |
| *In green fodder.* | | | | | | |
| β-carotene per kg. dry matter, mg. | 198 | 200 | 196 | 270 | 220 | 211 |
| Date of filling .. .. .. | 5/10 | 3/10 | 2/10 | 22/9 | 22/9 | 23/9 |
| *In silage.* | | | | | | |
| β-carotene per kg. dry matter, mg. | | | | | | |
| level 1 .. .. .. .. | 232 | 157 | 129 | — | — | — |
| date of sampling .. .. | 4/3 | 4/3 | 12/4 | — | — | — |
| level 2 .. .. .. .. | 217 | 164 | 117 | 385 | 284 | 266 |
| date of sampling .. .. | 18/3 | 18/3 | 27/4 | 3/5 | 3/5 | 20/3 |
| level 3 .. .. .. .. | 242 | 203 | 218 | 349 | 322 | 316 |
| date of sampling .. .. | 12/4 | 5/4 | 6/5 | 10/5 | 10/5 | 5/4 |

The silage samples in the majority of cases show a higher carotene content than the original green fodder sample. The reason for this has not been investigated ; possibly the increase in the carotene content may be due to the fact that the other organic substances in the silage suffer greater losses during storage than the carotene. This question should be made the subject of special investigation.

## 5. The Ability of Animals to Utilize the Carotene

The resorption of the carotene in the intestinal canal of animals has been investigated by Lund with pigs as experimental animals. The investigation was conducted partly with feeding stuffs containing carotene (carrots and lucerne hay meal) and partly with pure carotene in oil solution ; two series of experiments were carried out.

In the first series, some animals were fed with whole and others with finely divided carrots to test whether the degree of fineness of the fodder had any effect on the capacity of the animals to utilize the carotene. Young pigs were given 50 grm. carrots per day ; in the same series was included an experiment with 4 grm. carotene oil (with low carotene content) per day. It was not possible to determine any difference between carotene resorption by feeding with whole and finely divided carrots ; the resorption, that is, the carotene which was not found in the manure, amounted to 27 to 35 per cent. The carotene supplied in oil in this experiment showed 100 per cent resorption.

From this experiment, it was possible to deduce that oil has a certain importance for resorption of the carotene. For that reason a new experiment was carried out with carrots which were fed to one group without being mixed with oil, while another group was fed with the same quantity of carrots mixed with 50 gram. groundnut oil, and a third with the same quantity mixed with paraffin oil. Further, the resorption of carotene from hay meal, and also the resorption of carotene dissolved respectively in groundnut oil and butter fat, were investigated.

The carotene in carrots fed without oil is resorbed to about 33–43 per cent., thus approximately as in the preceding experiment. About the same resorption was obtained when the carrots were given together with groundnut oil, while the presence of paraffin oil, as was expected, reduced the resorption of carotene. Paraffin oil does not saponify and cannot therefore be resorbed, so that the carotene dissolved in it is lost. The carotene in groundnut oil and butterfat showed no difference as regards resorption.

The carotene in lucerne hay meal showed approximately the same degree of resorption as the carotene in carrots.

Lund has added some explanatory comments to his investigations and points out that by carotene resorption is meant the difference between the amount of carotene present in the food and the manure, and also that a portion of the carotene is possibly not resorbed but is destroyed in the intestinal canal. The figures cited indicate thus only the highest possible resorption which can be attained in the particular case. In the experiment in which the carrots were fed together with paraffin oil, 95 per cent of the carotene supplied was found in the dung, which Lund considers may go to show that the carotene is not destroyed in the intestines. It is, however, not demonstrated whether this also applies to the carotene which is not dissolved in paraffin oil.

## Concluding Remarks

Carotene is the parent substance of vitamin A and is therefore indispensable in the food of both man and animal. Vitamin A in a finished state does not occur in plants but only in animal products, chiefly in liver oils. Herbivorous animals, therefore, do not receive any vitamin A in the finished state with the fodder.

All domestic animals have a high carotene requirement, a fact to which as a rule their owners do not pay sufficient attention. Carotene—or vitamin A—deficiency leads to serious disturbances; here may be mentioned only poor growth, reduced fertility, increased susceptibility to diseases, and in extreme cases the occurrence of serious avitaminosis. The consequence is that the whole economy of animal husbandry is jeopardised. It should also be noted that a high carotene content in the plants produced, particularly the fresh meadow plants, also leads to a high carotene or vitamin A content in the animal products, especially in milk and eggs, which is of great importance for the health of the nation.

In the summer, when the animals are kept on pasture, the carotene and vitamin A content in their products is high, and the animals also store up large amounts, particularly in the liver. These reserves, however, do not last long, so that it is of the greatest importance that a sufficient quantity of carotene-rich fodder should be harvested and conserved in such a way that the carotene supply of the animals is ensured during the winter also.

## THE INFLUENCE OF LEY FODDER ON QUALITY OF MILK

A. Örborn

The value of the pasture is conditioned by the botanical composition of the ley, the manuring, the nature of the soil, and the technique of grazing.

The taste and aroma of milk are as a rule favourably affected if the pasture is not legume-rich but rather legume-deficient. The consistency of the butter, expressed in iodine value, becomes during grazing on grassy pasture leys in general not higher than can be satisfactorily regulated by the dairy-farmer. On pasture leys rich in legumes, and particularly in white clover, the iodine value on the contrary tends to reach such a level that satisfactory consistency of the butter cannot be obtained. It is now possible to remedy this defect by using a special salt.

The content of vitamins A and D is high during the grazing period. The content of vitamin D rises then to approximately double that in winter milk. If, as seems likely, a still more marked transition to spring calving takes place, there will be an increased need of storage of butter from summer production for consumption during the winter. This storage will make greater demands on summer milk and in particular on the quality of the pasture than hitherto. A thorough investigation of the pasture question from the point of view of feeding and of dairy products is now an urgent matter.

The pasture question has hitherto been dealt with more from the point of view of manuring than from that of feeding. Ley fodder conserved for winter feeding can be divided into field-dried hay, artificially dried hay, or hay meal and ley fodder ensiled in different ways. The botanical composition of the hay, the harvesting stage and the content of soil nutrients determine the feeding value of the hay not merely from the point of view of fodder but also in regard to its influence on the quality of the milk. It has been possible to determine that good lucerne hay and so-called hay of pasture type have had the effect of increasing the fat content of the milk. From the bacteriological point of view, the milk from hay-fed cows is superior to that from cows fed on concentrates, succulent fodder, and straw.

From experiments conducted in England it would appear that the carotene can be preserved by compressing artificially dried hay or hay meal into briquettes.

Ensiling of ley fodder according to the A.I.V. method has become increasingly general in recent years. A.I.V. fodder gives excellent consumption milk and good winter butter. If the placing of the fodder in the silo is carefully carried out and an adequate amount of acid is used, A.I.V. fodder suitable also for the production of milk for cheese-making is obtained.

On the conclusion of the address, Professor A. Platon stated that "oiliness" is perhaps the most serious defect in the quality of Swedish butter. The use of the so-called "special salt" is not very desirable. It should be regarded only as a makeshift, and it would be preferable if the necessity for its employment could be obviated by suitable feeding. Properly balanced feeding can effect an improvement in the consistency of butter. It is difficult to manufacture first-class cheese from milk of animals on fresh pasture, if this contains too much clover. An effort should be made to produce vitamin-rich butter by means of rational ley cultivation and by a rational distribution of the ley crops over the whole year, which is effected by suitable conservation of the said crops. One-sided feeding is never good for the quality of the dairy products, for which reason one should endeavour to distribute all feeding stuffs, not only ley crops, over the whole year. Of the ley crops conserved in different ways, hay is best for butter, cheese, and consumption milk. A.I.V. fodder affects the quality of cheese : some types cannot be manufactured from the milk of animals fed with this silage. Finally, Professor Platon pointed out that very different results can be achieved according as the material investigated derives from one district (or dairy) or another.

## EXPERIMENTS IN FODDER CONSERVATION

F. Jarl

In the autumn of 1942 the experimental farm of the Institute was provided with equipment for ensiling experiments comprising six 2·5 m. cement silos. In these was placed rather coarse aftermath clover from first-year leys. The green fodder was slightly too advanced in growth and was also wet with rain when placed in the silos. Ensiling was carried out :—

(1) according to the A.I.V. method ;
(2) by the addition of dilute formic acid ;
(3) by the addition of formic acid and phosphoric acid ;
(4) according to the Miko method ;
(5) according to the Miko method, but without Miko salt ;
(6) according to the cold fermentation process.

The greatest losses by expressed juice occurred with the A.I.V. and Miko methods, while the lowest fermentation losses of organic matter in the green fodder were obtained by the A.I.V. method. The total loss of organic matter amounted to 9 per cent for the A.I.V. method, while the other percentages of

loss were : addition of formic acid 16 per cent, addition of formic acid and phosphoric acid 16 per cent, the Miko method 18 per cent with, and 19 per cent without Miko salt, and in the cold fermentation silage 19 per cent.

Two feeding trials, one carried out at the Institute's experimental farm and the other at Rossared near Kungsbacka, showed that A.I.V. fodder and formic acid fodder were of equal value, while the cold fermentation silage gave a poorer yield.

In the discussion following the address *Dr. Elofson* emphasized the value of white clover in pasture leys ; its most serious defect is susceptibility to drought, in regard to which plant breeding should prove very helpful. Excellent results had been obtained at Valinge Storäng, where white clover was present in adequate amount in the stands. In Sweden, the proportion of white clover in the ley rarely exceeds 25 per cent. In Jutland, it amounts to 60 per cent, and when it falls to the Swedish level, special measures are taken to increase its contribution to the stand. In parts of Holland the pasture leys are composed almost exclusively of white clover. White clover is of high dietetic value : in pastures, it is the first plant to be eaten by cows. The statement that white clover in particular causes too high an iodine figure in the butterfat is open to doubt, and calls for proof.

*A. Örborn* stated his reasons for adopting a critical attitude to white clover. Grass, liberally manured with nitrogen, produces the best fodder. The susceptibility of white clover to drought reduced the very high value assigned to it by Dr. Elofson from the point of view of abundant and cheap fodder production. He considered that the midsummer minimum in production of the pastures described by Dr. Rappe depended on drought, and thus the position goes from bad to worse in pastures rich in white clover. As to its effect on the iodine figure, this amounted to 49·5 in the butterfat of animals that had grazed a fold with 80 per cent white clover—"pure oil, not butter." He thought that Dr. Elofson had confused dietetic value with palatability. The amount of carotene in yellow fat is quite small and is of but little significance, but it is a mistake to regard yellowish fat as a defect in healthy animals. It must, however, be borne in mind that certain diseased conditions in animals give rise to the same yellow colour.

*Mr. W. Weibull* stressed the high content of carotene in red carrots, pointing out that high-yielding red varieties are now available. He recommended an increased cultivation of red fodder carrots and also feeding trials with the same.

*Professor Olsson* gave some figures concerning silage : there did not appear to be any differences between formic acid and A.I.V. fodder. He reported that in dried and stored hay only one-sixth to one-seventh of the original content of carotene remained. If this is so, is it possible to improve artificially dried hay by storing it at a low temperature and in darkness ?

The speaker then dealt with some of the points raised. Considerable varietal differences as to carotene content occur among red carrots. He agreed with Mr. Weibull as to the great value of carrots for growing animals and full-grown horses ; the value of carrots will be taken into account in future experiments. The various methods of ensiling tested at the Animal Husbandry

Research Institute had yielded only slight and up to the present unreliable differences as to the carotene content : the loss of carotene, however, appeared to run parallel with the general loss of dry matter. The durability of carotene in dried ley crops is unfortunately very low. The manner of drying and the method of storage have, however, a considerable influence.

*Mr. J. E. Lindberg* stated that the carrots dried recently for the Svenska Spannmåls A.-B. (the Swedish Grain Co., Ltd.) had in the fresh state a carotene content of about 1,000 mg. per kg. dry matter. Through drying, the carotene content had fallen to approximately one-half. The greatest reduction appears to take place during the last part of the drying.

As to the carotene content in hay, he believed one could say that this, at any rate for Scanian hay, is about one-tenth of the amount in the fresh material. This figure has been determined by investigations with some fifty samples from the 1942 hay inventory in the province of Malmöhus.

Samples of this material, deriving partly from hurdled, partly from stacked hay from the same leys, were also investigated in this connexion. It was found that the stacked hay contained approximately 30 mg. carotene per kg. dry matter and the hurdled hay slightly more than 40 mg.

Practically no carotene was found in artificially dried hay. In the summer of 1942, a large number of samples of lucerne meal from Trollenäs and Steglinge were examined and several showed a very high carotene value. After storage for 8 months, however, the carotene content had fallen so considerably that a loss of approximately 47 per cent was recorded. During the period 1939–41 Dr. Bielefeldt (Denmark) conducted extensive investigations on the effect of storage on the carotene content of lucerne meal, and was able to establish that even under satisfactory conditions of storage it is impossible to avoid losses of 30 to 60 per cent during a period of storage.

Swedish meadow plants contain an abundant supply of carotene, but the problem appears to be to find suitable and reliable methods of conservation.

*Mr. Grahn* wished to know if a method could be found for the better conservation of the carotene content in artificially dried meadow plant material. Bielefeldt states that the material should be stored at the lowest temperature possible and with quite high atmospheric moisture. According to Bielefeldt, the moisture content of the lucerne meal should be in equilibrium with a relative atmospheric moisture of approximately 75 per cent, that is, in the dried condition it should contain about 13 per cent moisture.

*Mr. H. Sonesson* considered it impracticable to follow Bielefeldt's advice about conditions of storage and pointed out that his investigations referred to artificially dried hay meal stored in the ordinary way. In England, experiments had been conducted in compressing artificially dried hay into briquettes, with or without a suitable binding agent, such as molasses ; the carotene content was found to be unchanged at the end of a year. He was of opinion that the best methods of drying and storing could result in almost 100 per cent preservation of the carotene.

The lecturer dealt with the question of the effect of formic acid on pH value and conservation. A pH value of 4·1 to 4·2 is not satisfactory, because

with this degree of acidity the natural fermentation processes, which conservation is designed to prevent, still continue. It has been assumed that formic acid would have a specifically bactericidal effect, but this is very unlikely to be the case with the dilution recommended by the German firm which manufactures it. If formic acid promotes butyric acid fermentation, that is no advantage, as in acid conservation it is desired in particular to prevent this fermentation.

*Mr. A. V. Pehrsson*, referring to the satisfactory preservation of carotene in experiments with briquettes made from artificially dried, stored hay conducted in England, stated that pressing was costly, but that the problem can be solved in the same way as in Holland. There, ley fodder with molasses is pressed into cakes, and this is also done in some places in Sweden. The supply of molasses is certainly very limited, but by admixture with formic acid it is possible to neutralize the enzyme effect completely. It is hoped to be able to carry out experiments at Karlshamn.

*Mr. S. Olsson* wished to have experiments conducted with molasses as a means of conservation of green mass. He himself had tried the method with good results, but had discontinued its use owing to the lack of reliable figures showing its value in comparison with other accurately tested methods.

## SUGAR BEET AS A SOURCE OF FODDER

P. A. Olsson

Sugar beet occupies a special position among root crops as a commercial plant. It yields a crop which can be directly converted into cash, for which reason a farm with a contracted sugar beet plot attached is as a rule more sought after than one where sugar beet is not cultivated.

Sugar beet has for a long time been grown in Sweden almost exclusively for industrial purposes, more especially for the manufacture of sugar. During recent years, however, the question of its cultivation for fodder has been frequently discussed, possibly as a result of the experience of Danish farmers in this connexion.

Sugar beet growers in Denmark are permitted to grow sugar beets for fodder also provided that the sugar factory is informed of the size of the area on which the latter are cultivated and that these plots are kept well separated from the plot in respect of which a contract has been entered into with the sugar factory.

With the object of providing in Sweden as reliable a basis as possible which could be used in comparing mangolds, fodder sugar beets and sugar beets with one another in respect to yield, in 1940 the Swedish Seed Association began at Svalöf a series of trials which are still in progress and in which the above types of roots are included. As therefore figures for 4 years are available some of the data are presented in Table 1.

TABLE 1. RESULTS OF A COMPARATIVE TRIAL WITH BEETS

## SUGAR BEET

### ROOTS

| Year of trial | Kg. roots per ha. | | | Per cent | | | Yield per ha. in kg. | | | Relative no. for | | | Number of food units | Grm. crude protein per food unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before washing | % soil | After washing | Dry matter | Cane sugar | Crude protein | Dry matter | Cane sugar | Crude protein | Dry matter | Cane sugar | Crude protein | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1940 | 30,100 | 6·0 | 28,294 | 25·29 | 17·10 | 1·1 | 7,156 | 4,980 | 311 | 100·0 | 100·0 | 100·0 | 6,505·5 | 48 |
| 1941 | 39,800 | 5·9 | 37,452 | 25·44 | 18·23 | 1·1 | 9,528 | 6,827 | 412 | 100·0 | 100·0 | 100·0 | 8,661·8 | 48 |
| 1942 | 38,700 | 8·2 | 35,527 | 24·84 | 18·33 | 0·9 | 8,825 | 6,512 | 320 | 100·0 | 100·0 | 100·0 | 8,022·7 | 40 |
| 1943 | 50,520 | 7·1 | 46,933 | 23·86 | 17·53 | 1·1 | 11,198 | 8,227 | 516 | 100·0 | 100·0 | 100·0 | 10,180·0 | 51 |
| Average | 39,780 | 6·9 | 37,052 | 24·77 | 17·91 | 1·06 | 9,177 | 6,637 | 390 | 100·0 | 100·0 | 100·0 | 8,342·5 | 46·7 |

### TOPS

| | | Tops as % of roots | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1940 | — | 106·0 | 29,980 | 17·59 | 1·80 | 2·86 | 5,273 | 541 | 857 | 100·0 | 100·0 | 100·0 | 4,056·1 | 211 |
| 1941 | — | 115·6 | 43,280 | 16·47 | 2·38 | 2·28 | 7,128 | 1,028 | 987 | 100·0 | 100·0 | 100·0 | 5,483·1 | 180 |
| 1942 | — | 92·3 | 32,800 | 16·04 | 2·04 | 1·75 | 5,260 | 670 | 574 | 100·0 | 100·0 | 100·0 | 4,046·2 | 142 |
| 1943 | — | 52·9 | 24,820 | 14·69 | 1·30 | 2·04 | 3,646 | 323 | 506 | 100·0 | 100·0 | 100·0 | 2,804·6 | 180 |
| Average | — | 88·3 | 32,720 | 16·28 | 1·96 | 2·23 | 5,327 | 641 | 731 | 100·0 | 100·0 | 100·0 | 4,097·5 | 178·4 |

### TOTAL

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1940 | — | — | — | — | — | — | 12,429 | 5,521 | 1,168 | 100·0 | 100·0 | 100·0 | 10,561·6 | 111 |
| 1941 | — | — | — | — | — | — | 16,656 | 7,855 | 1,399 | 100·0 | 100·0 | 100·0 | 14,144·9 | 99 |
| 1942 | — | — | — | — | — | — | 14,085 | 7,182 | 894 | 100·0 | 100·0 | 100·0 | 12,068·9 | 74 |
| 1943 | — | — | — | — | — | — | 14,844 | 8,550 | 1,022 | 100·0 | 100·0 | 100·0 | 12,984·6 | 79 |
| Average | — | — | — | — | — | — | 14,504 | 7,277 | 1,121 | 100·0 | 100·0 | 100·0 | 12,440·0 | 90 |

The varieties included in the comparative trial dealt with here are Röd Eckendorfer, Barres Halvlång (=medium-long) Rubra II, Nova (a white, green-topped fodder sugar beet) and sugar beet—all Svalöf strains. The trial is laid out according to the row method, thus with the 5 varieties in unbroken sequence through all the replications, the number of which is limited to 6. The distance between the rows is 50 cm. and the distance between the plants 25 cm. Each variety is sown in 3 rows 21 m. long, from which only the plants on a 20 m. long section of the central row are weighed and analysed during harvesting, and to which therefore the primary figures used in the calculation of the experimental results refer. The plants in the two side rows as well as in

ARRIED OUT BY THE SWEDISH SEED ASSOCIATION AT SVALÖF, 1940–43.

## FODDER SUGAR BEET (NOVA)

### ROOTS

| Kg. roots per ha. | | | Per cent | | | Yield per ha. in kg. | | | Relative no. for | | | Number of food units | Grm. crude protein per food unit | Relative no. for root yield: Sugar beet =100 | Mean error in % of root yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Before washing | % soil | After washing | Dry matter | Cane sugar | Crude protein | Dry matter | Cane sugar | Crude protein | Dry matter | Cane sugar | Crude protein | | | | |
| 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 54,000 | 3·0 | 52,380 | 16·20 | 9·40 | 0·8 | 8,486 | 4,924 | 419 | 118·6 | 98·9 | 134·7 | 7,714·5 | 54 | 185·1 | ±2·26 |
| 73,700 | 1·2 | 72,816 | 15·40 | 9·90 | 0·7 | 11,214 | 7,209 | 510 | 117·7 | 105·6 | 123·8 | 10,194·5 | 50 | 194·4 | ±1·81 |
| 73,900 | 5·3 | 69,762 | 14·74 | 9·70 | 0·6 | 10,283 | 6,767 | 419 | 116·5 | 103·9 | 130·9 | 9,348·2 | 45 | 196·4 | ±1·76 |
| 89,040 | 0·8 | 88,328 | 13·98 | 8·90 | 0·7 | 12,348 | 7,861 | 618 | 110·3 | 95·6 | 119·8 | 11,225·5 | 55 | 188·2 | ±1·74 |
| 72,660 | 2·5 | 70,822 | 14·94 | 9·45 | 0·69 | 10,583 | 6,690 | 492 | 115·3 | 100·8 | 126·2 | 9,620·7 | 51 | 191·1 | — |

### TOPS

| Tops as%of roots | | | | | | | | | | | | | Relative no. for amount of tops. Sugar beet =100 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55·5 | 29,060 | 14·64 | 1·39 | 2·43 | 4,255 | 403 | 706 | 80·7 | 74·5 | 82·4 | 3,273·1 | 216 | 96·9 | — |
| 39·6 | 28,840 | 13·15 | 1·83 | 2·04 | 3,792 | 529 | 588 | 53·2 | 51·5 | 59·6 | 2,916·9 | 202 | 66·6 | — |
| 42·0 | 29,300 | 11·57 | 0·89 | 1·54 | 3,390 | 260 | 451 | 64·4 | 38·8 | 78·6 | 2,607·7 | 173 | 89·3 | — |
| 22·5 | 19,840 | 11·73 | 0·83 | 2·18 | 2,327 | 185 | 433 | 63·8 | 57·3 | 85·6 | 1,790·0 | 242 | 79·9 | — |
| 37·8 | 26,760 | 12·86 | 1·29 | 2·04 | 3,441 | 344 | 545 | 64·6 | 53·7 | 74·6 | 2,646·9 | 205·9 | 81·8 | — |

### TOTAL

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| — | — | — | — | — | — | 12,741 | 5,327 | 1,125 | 102·5 | 96·5 | 96·3 | 10,987·6 | 102 | — | — |
| — | — | — | — | — | — | 15,006 | 7,738 | 1,098 | 90·1 | 98·5 | 78·5 | 13,111·4 | 84 | — | — |
| — | — | — | — | — | — | 13,673 | 7,027 | 870 | 97·1 | 97·8 | 97·3 | 11,955·9 | 73 | — | — |
| — | — | — | — | — | — | 14,675 | 8,046 | 1,051 | 98·9 | 94·1 | 102·8 | 13,015·5 | 81 | — | — |
| — | — | — | — | — | — | 14,024 | 7,034 | 1,036 | 96·6 | 96·6 | 92·4 | 12,267·6 | 84 | — | — |

the outermost half metre at each end of the central row where this borders on the paths serve only as edging plants to eliminate the "neighbouring" and "marginal effect." The competing varieties differ greatly from one another in respect to method of growth and type of tops, and therefore plants of these which are in too close proximity cannot avoid within the boundary area more or less influencing each other's development during the growing period. Such disturbances cannot be tolerated under any circumstances if the claims of the experimental results to reliability are to be maintained. The actual size of plot is therefore after deduction of the marginal protection mentioned: 0·5 m. × 20 m. = 10 sq. m. At a suitable time the trial plots are singled

after the distance between the plants has been fixed by a marker drawn across the rows, by means of which the number of plants per plot becomes as far as possible the same, which is of the greatest importance in root crop trials. Sowing and harvesting are carried out at times which may be considered to be usual for the root crop in question in the locality. The trials are laid out on the shifts in the rotation which are due to carry root crops (after autumn-sown cereals). The soil on the areas which thus are employed for laying out the trials is usually a medium-heavy, not too humus-rich clay mould with alkaline reaction. Manuring : 15–20,000 kg. more or less well decomposed farmyard manure ploughed in during the previous autumn, 200 kg. 20 per cent superphosphate, 100 kg. 40 per cent potash salts and 400 kg. calcium nitrate per hectare. The calcium nitrate is applied as a top dressing, half the dose immediately after the conclusion of sowing and half after singling. The seed is sown by means of a Planet Junior drill on the previously marked out field. After harvesting and weighing of the crop one-quarter of the roots are taken from each plot for analysis, and in the same way samples are taken of the weighed tops. The roots to be analysed are washed. By determinations of weight before and after washing (after the roots have been allowed to dry) the percentage of soil was ascertained for each variety. In the root crop laboratory the samples of roots and tops were tested for percentage dry matter and (polarimetrically) percentage cane-sugar. But in addition in the laboratory of the chemical department complete analyses of both roots and tops were made (determinations of dry matter, crude protein, digestible protein, total sugar, fibre, crude fat, and ash). In the samples of the tops the carotene- and vitamin C contents were also determined.

From considerations of space it has not been possible to include in the table the figures from all these determinations ; and for the same reason it has been possible on this occasion to institute a comparison between only two of the varieties included in the trial, namely sugar beet and Nova. As, however, the latter may be considered to be a fairly good representative of fodder sugar beets with not too high dry matter concentration, the comparison should be quite elucidative. The figures in the table cannot be minutely examined, but a few of the more noteworthy figures or groups of figures will be discussed in detail.

The differences in dry matter content, as in sugar content, between the two varieties included in the trial are very striking, especially as regards the roots. On the average the ratio between the values for sugar beet and fodder sugar beet respectively is 24·77 : 14·92 and 17·91 : 9·45. From column 30 in the table it is evident, however, that fodder sugar beet has given nearly twice as large a root yield as sugar beet, and it is therefore not so surprising to find from column 25 that the former has on the average surpassed the latter by not less than 15 per cent in yield of dry matter per unit area. The amount of crude protein per hectare was nearly 25 per cent higher in the root yield of fodder sugar beet than in that of sugar beet, in spite of the fact that the content of crude protein, as is seen, was higher in the root of sugar beet. What is, however, most surprising is that fodder sugar beet in the root crop has on the average given quite as high a yield of sugar per unit area as sugar beet. If the

number of food units in the amounts of roots harvested per hectare be calculated—via the dry matter with 1·1 kg. dry matter =1 food unit—for both varieties, it is found that fodder sugar beet on the average has yielded about 1,200 to 1,300 food units more than sugar beet (see columns 14 and 28). The amount of crude protein per food unit is also very slightly higher in fodder sugar beet.

But as regards tops, sugar beet has on the average of the 4 trial years given approximately a 20 per cent larger yield per hectare than fodder sugar beet : in addition sugar beet tops, as is seen from the analysis figures, are considerably richer in dry matter than fodder sugar beet tops. The yield of dry matter per unit area is about 1·5 times as large for sugar beet as for fodder sugar beet. The sugar content in the former is also on the average 0·7 per cent higher than in the latter. The crude protein content on the other hand is almost the same for both kinds of tops. In calculating the yields of tops in food units, 1·3 kg. dry matter has been regarded as equivalent to 1 food unit. During the 4-year period on the average 1,450 food units more per hectare have been harvested from sugar beet tops than from fodder sugar beet tops, for which reason sugar beet, in spite of a considerably lower yield of roots than fodder sugar beet, in total yield stands slightly higher than fodder sugar beet—172 food units higher. Perhaps it should be remarked in this connexion that the yields of tops during the first three years of the trial and as far as sugar beet is concerned particularly during the first two years were abnormally large—thus during 1941 in the case of sugar beet the quantity by weight of tops harvested per hectare was 15 per cent higher than of roots and during 1940 it was 6 per cent higher. Normally the yield of tops even of sugar beet is lower than the root yield, about 50 to 60 per cent of this, and therefore the figure for 1943, 52·9 per cent of the root yield, may be considered as fairly normal. The severe drought during the early part of the summer and the wet weather during the latter part of the summer and in the autumn of the preceding years may well be considered to be the cause of this unusually luxuriant growth of tops in proportion to the size of root. The yield of tops relative to the yield of roots in fodder sugar beet too shows abnormally high values during the first three years (see column 17 of the table) but not to so marked a degree as is the case with sugar beet. The normal values for the percentage tops for fodder sugar beet are in the neighbourhood of 30.

In practice it seems to be impossible to collect and utilize all the tops from the root crop plots. Even in the most satisfactory instances one can scarcely count on much more than two-thirds of the yield of tops being harvested and utilized in one way or another for fodder. When the beet is pulled up and shaken clean, a larger or smaller number of leaves are loosened, fall to the ground and are trampled down, and during topping itself still more are lost. If in addition the tops, as often happens, are used to cover the heaps of roots when these after harvesting are left lying out on the field until they can be carted away, much more than one-third of the quantity of tops harvested is lost, at any rate when regarded as fodder. Such tops may be considered to have a certain value as green manure, although this is of course considerably less than their value as fodder.

When therefore as here figures for yields of tops are calculated according to weight data from experimental weighings, from the point of view of practice one is dealing with quite fictitious values. The hectare yields of food units of tops which are obtained in this way should therefore be reduced by at least one-third before they are added to the hectare yields of food units in roots in order that the total yield figure may in some measure be considered to correspond with what is in fact obtained from the varieties of root crops cultivated ; two-thirds of the average food unit figures for harvested sugar beet tops is $\frac{4097{\cdot}5 \times 2}{3} = 2{,}731{\cdot}7$ food units and of harvested fodder sugar beet tops $\frac{2{,}646{\cdot}9 \times 2}{3} = 1{,}764{\cdot}6$ food units. If these reduced but somewhat more realistic numerical values for yields of tops of sugar beet and fodder sugar beet are added to the average figures of the number of food units harvested per hectare in the roots for the respective varieties, the following average values for total yields are obtained :—

Sugar beet, in roots 8,342·5 food units + in tops 2,731·7 food units = 11,074·2 food units.

Fodder sugar beet, in roots 9,620·7 food units + in tops 1,764·6 food units =11,385·3 food units. As is seen, fodder sugar beet's higher harvest yield in roots per unit area in this case makes itself slightly more felt so that in total yield also it surpasses sugar beet somewhat—by 300 food units per hectare.

The sugar beet strain included in the trials dealt with here was Svalöf sugar beet, strain 015, and it is therefore of interest to see how it compares in respect to yield with the Hilleshög strain, which is more generally grown in Sweden. During all the years that the above-mentioned trials have been in progress plots from post-stock seed of these two strains of sugar beet have competed alongside each other in special comparative varietal trials on the same experimental field as the competitive trials with mangolds, fodder sugar beet, and sugar beet, and were laid out under the same external conditions as the latter. The results are summarized in Table 2, from which it is clear that Svalöf sugar beet, strain 015, does not give a poorer harvest yield than the generally grown industrial sugar beet. Data on percentage of dry matter and yield of dry matter are lacking in this table in which percentages of sugar and yields of sugar only are recorded : this is owing to the fact that only the content of sugar and not the percentage dry matter was determined in root samples from different sections in the comparative varietal trials with sugar beets. The correlation between percentage dry matter and percentage sugar in beets is, however, very fixed and positive, and therefore one can with fairly great certainty conclude from a high sugar content that the dry matter content is high.

In Denmark, where as stated above sugar beets are to a certain extent grown for fodder, strains specially bred for the purpose are employed : there are quite a number to choose from. They are in general characterized by a slightly lower dry matter- and sugar content than the sugar beet cultivated

for industrial purposes, a higher root yield and also a root form more convenient for lifting. Judging from reports on Danish trials, these strains give a slightly larger total yield per unit area than fodder sugar beet strains tested in trials which are grown in that country.

## Table 2

Results of Comparative Trials with Sugar Beets carried out by the Swedish Seed Association at Svalöf during the years 1940–43.

| Year of trial | Sugar Beet Strain (Hilleshög) of the Swedish Sugar Manufacturing Co., Ltd. Seed for Growers | | | | | | | Svalöf Sugar Beet, Strain 015 | | | | | | | Mean error in % of root yield |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Root yield per hectare in kg. | | | % sugar | Yield per ha. kg. sugar | Relative no. for | | Root yield per hectare in kg. | | | % sugar | Yield per ha. kg. sugar | Relative no. for | | |
| | Before washing | % soil | After washing | | | Roots | Sugar | Before washing | % soil | After washing | | | Roots | Sugar | |
| 1940 | 36,500 | 5·6 | 34,456 | 18·30 | 6,305 | 100·0 | 100·0 | 38,100 | 5·0 | 36,195 | 18·00 | 6,515 | 105·0 | 103·3 | ±2·24 |
| 1941 | 42,300 | 6·5 | 39,551 | 18·47 | 7,305 | 100·0 | 100·0 | 43,700 | 5·3 | 41,384 | 18·00 | 7,449 | 104·6 | 102·0 | ±1·18 |
| 1942 | 40,400 | 10·6 | 36,118 | 17·03 | 6,151 | 100·0 | 100·0 | 39,800 | 9·6 | 35,979 | 17·40 | 6,260 | 99·6 | 101·8 | ±1·70 |
| 1943 | 49,120 | 6·2 | 46,075 | 18·13 | 8,353 | 100·0 | 100·0 | 53,700 | 5·6 | 50,693 | 18·23 | 9,241 | 110·0 | 110·6 | ±1·80 |
| Average | 42,080 | 7·20 | 39,050 | 18·00 | 7,029 | 100·0 | 100·0 | 43,875 | 6·30 | 41,063 | 17·94 | 7,366 | 105·2 | 104·8 | |

From what has been stated here it will be evident that sugar beet certainly possesses a high cultivation value also as fodder. But it is clear too that it is so far from being in a class apart as regards harvest yield that only in the event of the yield of tops being harvested in the most careful manner possible does it reach the level of the better fodder sugar beet (and mangold) strains. Owing to the sugar beets being particularly highly concentrated they meet the requirements of the times in the sphere of root crop cultivation, and are suitable as is known owing to their high content of dry matter, and possibly not least owing to the fact that a large part of that dry matter consists of readily digestible sugar, for the feeding of horses and pigs. For this latter animal group with, compared with cattle, its small digestive canal the high concentration is a very important and valuable property in fodder. The sugar in the digestive canal is readily taken up into the blood and converted with very small losses into energy or fat in the animal body. Experience gained in Denmark shows, however, that in feeding cattle with such highly concentrated root crops great care must be exercised, otherwise what is known as beet poisoning may occur. In contrast to what is the case with mangolds and fodder sugar beets, as a large quantity of soil adheres to sugar beets they must be washed before they are given to the animals ; if this is not done, there is a certain risk of digestive disturbance resulting in poorer utilization of the

fodder. Owing to the hardness of the flesh of the roots of sugar beet it is also frequently necessary for these to be cut into slices or strips before feeding. All this entails work. Harvesting of sugar beet as is known also requires much labour. A fodder sugar beet of, for example, the Nova type is as easily harvested as a Barres beet. On the other hand it cannot be denied that some labour is saved owing to the higher concentration in sugar beet compared with fodder sugar beet in so far as in the former one handles a smaller bulk per food unit supplied than in the latter.

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